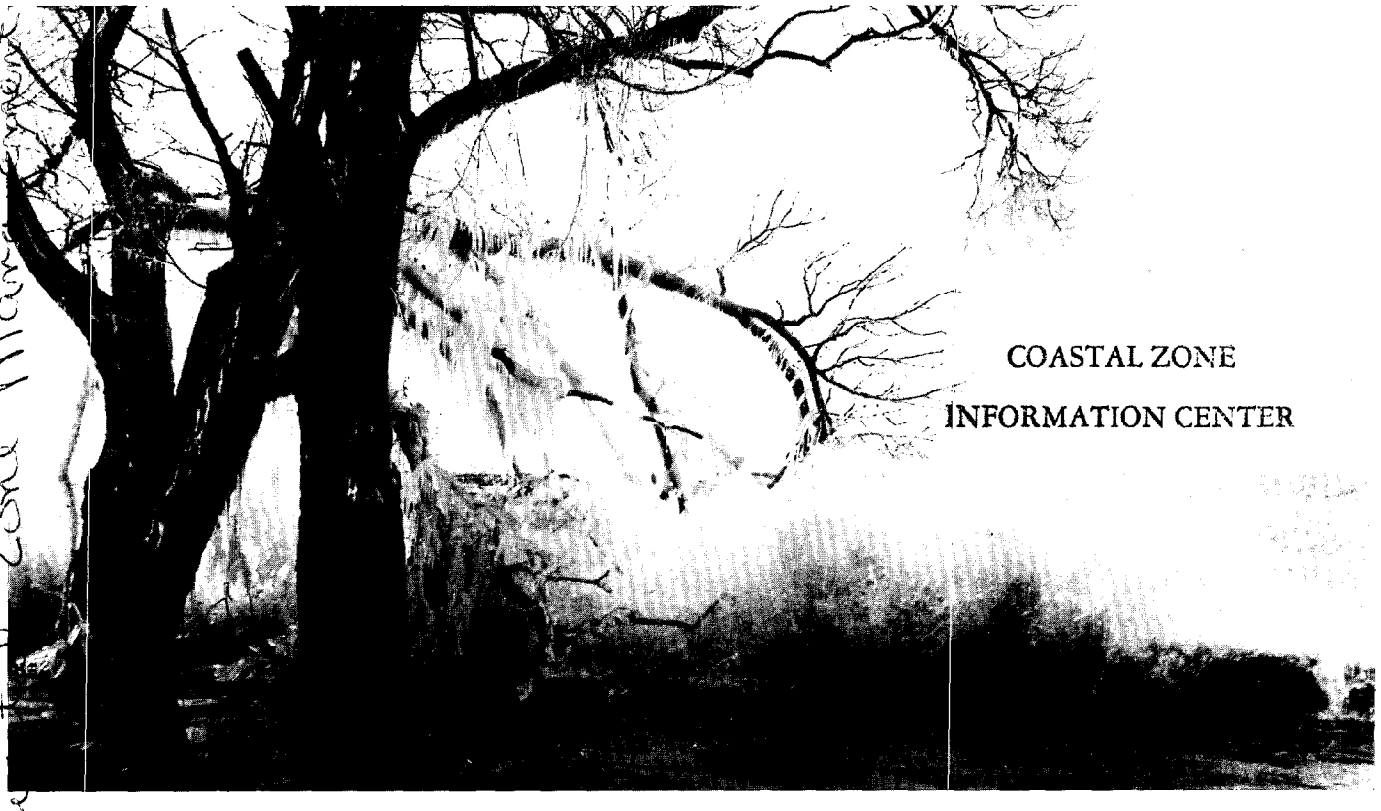
W.P.

MARCH 1975

Lake Ontario and the St. Lawrence River:

ANALYSIS OF AND RECOMENDATIONS CONCERNING HIGH WATER LEVELS

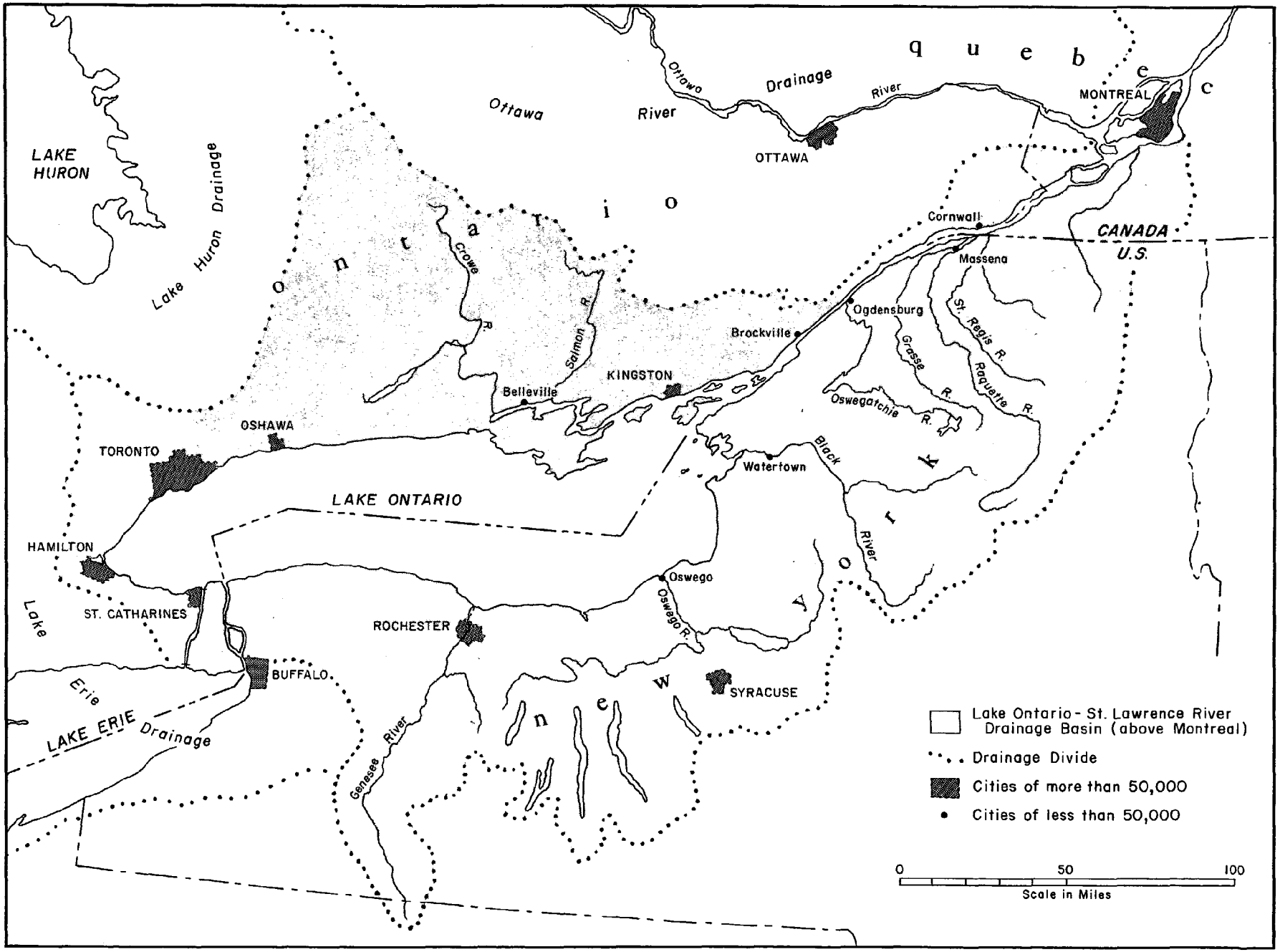


STATE OF NEW YORK

ST. LAWRENCE-EASTERN ONTARIO COMMISSION

317 Washington Street, Watertown, New York 13601

STUDY AREA


LAKE HURON
Lake Huron Drainage
Ottawa River
Ottawa River Drainage
OTTAWA
MONTREAL
Quebec
Ontario
Crowe R.
Salmon R.
Cornwall
CANADA
U.S.
Massena
Ogdensburg
St. Regis R.
Grasse R.
Raquette R.
Oswegatchie R.
Brockville
KINGSTON
Belleville
OSHAWA
TORONTO
Watertown
Black River
LAKE ONTARIO
HAMILTON
Oswego
Oswego R.
Mohawk River
Lake Erie
ST. CATHARINES
ROCHESTER
BUFFALO
SYRACUSE
LAKE ERIE Drainage
Genesee River
New York
Lake Ontario - St. Lawrence River Drainage Basin (above Montreal)
Drainage Divide
Cities of more than 50,000
Cities of less than 50,000
0
50
100
Scale in Miles

ST. LAWRENCE-EASTERN ONTARIO COMMISSION

317 WASHINGTON ST., WATERTOWN, N. Y. 13601
PHONE (315) 782-0100
EXTENSION 263-4

JOSEPH A. ROMOLA, Chairman WILLIAM E. TYSON, Executive Secretary

To the Governor and the Legislature:

I am pleased to submit the report of the St. Lawrence-Eastern Ontario Commission analyzing the problem of controlling the water levels of Lake Ontario and the St. Lawrence River. This report has been prepared in compliance with Chapter 701 of the Laws of 1974.

Our investigation indicates that the problems--associated with changing lake levels and storm surges--have been occasioned by a series of institutional constraints and governmental inertia which has failed to keep pace with changing riparian land uses, a growing public awareness of the value of the natural environment, and recent hydrological events within the Great Lakes Basin.

Major findings indicate:

--that criteria established by the International Joint Commission in their Orders of Approval dated October 29, 1952, as amended, should be re-examined in light of the passage of time and changes in Great Lakes Basin precipitation rates experienced in the past twenty-one years.

--that lack of implementation of flood plain management techniques has allowed development in areas considered hazardous with or without lake level regulation.

--that riparian developments and productive natural resources on the New York portion of the Lake Ontario Shoreline do not lend themselves to protection by structural measures alone.

In summary, to maximize beneficial use of the lands bordering and the waters of Lake Ontario, a combination of improved lake level regulation, expanded flood plain management programs, and construction of selected structural measures must be developed.

Within the limits of time and staff resources, this is the Commission's perception of the problem and of the directions in which solutions must be sought.

This report seeks objectivity, yet recognizes that just as judgment and biases are credited to various interest groups, our findings, too, may be biased, based on our belief that an additional effort will provide greater benefits for the people of the State of New York.

The Commission recommends that the New York State Legislature transmit these findings to the Congress of the United States, requesting renewed efforts to maximize the benefits yet to be realized from our Fourth Sea Coast.

Respectfully submitted,

Joseph A. Romola
Chairman

JAR:ab

Palm, Daniel John

ST. LAWRENCE-EASTERN ONTARIO COMMISSION

LAKE ONTARIO AND THE ST. LAWRENCE RIVER: ANALYSIS OF AND RECOMMENDATIONS CONCERNING HIGH WATER LEVELS

MARCH 1975

Joseph A. Romola
Chairman

William E. Tyson
Executive Director

Report's Principal Author:
Daniel J. Palm, Ph.D

317 Washington Street
Watertown, New York 13601

Acknowledgments

The Commission and author would like to express their graditude to those agencies and individuals who provided information requested in the development of the draft of this report. In addition, those who expended considerable effort in reviewing the technical aspects of the draft report and in doing so provided comments that aided in the improvement and clarification of the text, as evidenced by the final report, deserve recognition for the professional manner in which they dealt with the issues raised in the report.

ANALYSIS OF AND RECOMMENDATIONS FOR CONTROL OF THE WATER LEVEL OF LAKE ONTARIO AND THE ST. LAWRENCE RIVER

List of Tables

List of Tables (cont.)

List of Figures

List of Figures (cont.)

CHAPTER I

INTRODUCTION

The Great Lakes Basin system is one of the largest fresh water lake systems in the world. It is a complex hydrologic system located in the heavily populated and industrialized portions of both Canada and the United States. Accordingly, man has encroached upon the flood hazard zone in order to increase the benefits he can derive from usage of them.

Under normal conditions this encroachment resulted in relatively minor problems. However, under conditions of above average precipitation as has been experienced over the past couple of years, it has led to substantial damage. The limits of man's ability to control the lake levels, to provide the required structural protection and to restrain his own activities, to the extent required, in the hazardous zones in an effort to limit the extent of these damages have been evidenced. This evidence is in the form of unprecedented damage to both property and natural resources along and on the flood plain areas of the lakes and rivers of the system.

A. The Problem

Man's efforts to date have not prevented large amounts of damage from being inflicted on the users of the waters of and the lands surrounding Lake Ontario and the St. Lawrence River. Acceptable, effective methods to reduce these damages are required.

Regulation of Lake Ontario's water level is undertaken in consideration of demands placed by navigational interest, power producers and riparian land owners within the criteria set forth in the Orders of Approval and implemented through the Plan of Control 1958-D. Serious questions have been raised relative to the equity of the current method of implementing the control plan, the representation on the board setting control policy and the technical soundness of the control plan itself.

Flood plain management implementation is primarily the responsibility of local levels of government while relief in times of disaster has primarily been undertaken by the federal government. Has this division of responsibility

reduced the incentive for developing and implementing limitations to man's activities in the flood hazard zone?

Examination of current flood damage reduction methods will provide answers to these and other questions regarding the effectiveness during periods of high water of efforts implemented by man. From this, recommendations relating to the various flood damage reduction techniques and to the interest groups can be developed.

B. The Objectives

The objectives of this study were:

1. to develop an understanding of the Great Lakes System.

2. to determine who has been bearing the costs incurred by and the benefits derived from the high water in the period January, 1973 through August, 1974.

3. to evaluate methods of flood damage reduction to determine if total damages were minimized during the period January, 1973 through August, 1974.

4. to make recommendations relating to flood damage reduction methods and the impacted interest groups.

C. St. Lawrence-Eastern Ontario Commission-Role and Responsibility

The St. Lawrence-Eastern Ontario Commission was created within the Executive Department of New York State effective July 1, 1974. Prior to this the Commission had been operating under the auspices of the Office of Planning Services.

The Commission's interest in the problem associated with high water levels has been extensive. Numerous public statements relating to this problem have been released which discussed the situation, the problems that might arise and the actions that could be taken to alleviate the problems. Prior to the storm of March 18 and 19, 1973, which led to a declaration of a disaster by the federal government, the Commission hosted two public forums in an attempt to provide information to the residents and property owners within the area serviced by the Commission.

Due to the Commission's attempts to address the problem of high water levels, the New York State Legislature, in 1973, directed the Commission in addition to its primary mandate

to "study the problem of controlling the water level of Lake Ontario and the St. Lawrence River and to make recommendations to federal, state, municipal and private agencies."

The primary mandate of the Commission is to "insure optimum conservation, protection, preservation, development and use of the unique, scenic, esthetic, historic, ecological, recreation, economic and natural resources of the St. Lawrence Eastern Ontario Area."

A further purpose of the legislation forming the Commission is "to focus the responsibility for developing a long-range area policy in an area wide forum reflecting statewide concern as well. This policy shall recognize the major area wide and state interest in the conservation, use and development of the area's resources, and at the same time, provide a continuing role for local government."

D. Study Approach

The approach taken in achieving the objectives set forth will be to develop an understanding of the Great Lakes drainage system as it influences Lake Ontario and the St. Lawrence River. In addition, analysis of current uses of the lands and waters of the basin will be undertaken. From this an evaluation of the impact of the water levels during the period of January 1973 through August 1974 will be made.

A general review of damage reduction techniques will be undertaken. This will include a discussion of which technique(s) is applicable under varying conditions. With an understanding of their applicability, currently utilized damage reduction techniques will be examined to determine the degree to which they are being implemented within the study area.

Throughout each step of the study important findings will be extracted. Each finding will be supplemented with a series of recommendations indicating not only what ought to be done but also indicating which level of government has the responsibility for carrying through with implementation.

E. Finding and Recommendations

The analyses described in the following chapters yielded a series of findings that relate to existing water resource management in the Lake Ontario and St. Lawrence River basins. These findings were classified

as relating to either institutions, physical works or data/research needs.

From each finding a set of recommendations was developed. Some of the recommendations entail significant changes in the established heirarchy of institutional entities responsible for water resource management in the basin. Others merely call for additional data and/or study. However, in total they call for a re-evaluation of current philosophies and institutional arrangements for water resource management. This is required due, in part, to the limited flexibility allowed existing entities. These limits to flexibility are primarily institutionally imposed restraints.

Following are the major recommendations and findings. They are not listed in any order of priority since none taken singularly can solve the problems. But taken together as a comprehensive program, improvements in the water resource management of the Lake Ontario-St. Lawrence River System would result.

Table 1 reflects the recommendations set forth with the level(s) of government - international, federal, state, regional and local - that hold the primary responsibility for implementing the recommendation. This responsibility falls primarily on the international, federal and state levels of government as is expected due to the size and location of Lake Ontario and the St. Lawrence River and the many governmental entities encompassed within their drainage basins.

1. Institutions

Finding 1: Flood plain management has not been effectively implemented by minor civil divisions in the past. This is evidenced by the damages incurred by recent storms (over 25 million dollars alone reported on the United States portion of Lake Ontario during the storm of March 18-19, 1973). (IV-A-3_{a+c}, VI-C).[1]

Recommendations:

1-1. Implementation of the federal flood insurance program be accelerated in order that all persons in the flood hazard zone are eligible for insurance.

---

[1]These numbers refer to the Sections and Subsections of this report which provide the background from which the finding was developed.

This acceleration could be accomplished primarily by increasing the rate at which technical data relative to flood hazards are made available to local communities; by providing technical assistance, through a state or regional agency, in the development of ordinances required by the Flood Insurance Program; and through strict enforcement of the provisions of the 1974 Disaster Relief Act and the 1973 Flood Disaster Protection Act.

1-2. Efforts should be made to ensure that the flood damage reduction techniques - zoning, building regulations, flood proofing, etc. - are implemented and enforced as required by the federal flood insurance regulations and the New York State flood plain management bill.

Finding 2: Current institutional arrangements do not provide for full representation of the many interests in the Lake Ontario - St. Lawrence River basin. (VI-A-2)

Recommendation:

2-1. Representation of riparian owners should be added to The International St. Lawrence River Board of Control. This representation could be in the form of individuals with expertise in water resources management from Canada and the United States provided by their respective governments to represent riparian owners and their interests.

In addition broader representation should be provided in the planning process through which plans of regulation are developed. This could be accomplished through representation of environmental groups, states, riparian interest and others on committees of planning or investigative boards.

Finding 3: Flooding occurs in the Lake St. Louis - Montreal section of the St. Lawrence River when the combined flow of the St. Lawrence River and the Ottawa River exceeds approximately 500,000 cfs. The current burden of preventing this flooding is control of the approximately 300,000 cfs flow of the St. Lawrence River. (IV-A-3b)

Recommendations:

3-1. Joint efforts between the United States and Canada should be undertaken to determine more satisfactory ways to manage the combined flow of the St. Lawrence and Ottawa Rivers to afford protection to the Montreal area.

This may require additional Canadian development of the Ottawa River. Such action however should be part of an overall management program for the Lake Ontario - St. Lawrence River basin. This is critical because flood conditions along the Ottawa River typically coincide with seasonal high water levels on Lake Ontario, and the restriction of flows from Lake Ontario, to prevent damages in the Montreal area, increases the probability of damages occurring on Lake Ontario.

3-2. New York State should strongly urge the federal government to promote and develop an amended international institution that is capable of dealing effectively with the problem of lake level regulation. At the least this will require a revamping of the International Joint Commission's boundary water management functions, at the most it may require development of a new institution and the dissolution of existing ones.

The revamping suggested should include, as outlined in recommendation 2-1, methods of providing broader representation in the planning process. This is preferred to development of a totally new institution. However, if the problems of lake level regulation cannot be effectively accomplished through this arrangement then the stronger measure of development of new institutional arrangement should be considered.

Finding 4: Of the $22 million loaned by the Small Business Administration as a result of the March 18-19, 1973 storm approximately 90 percent or $20 million was "forgiven" and not subject to repayment. (IV-3-a)

Recommendations:

4-1. Current government policies relative to disaster loans must be re-evaluated due to the magnitude of losses being incurred and to the potential for additional losses. People who build in hazardous areas in order to enjoy certain amenities - the beach, a view of the lake, etc. - should be willing to assume the risk, i.e. no subsidized flood insurance, involved with such locations. Forgiveness loans reduce this risk, as do tax breaks for damages, and in effect says "build here in the hazard area zone and enjoy the amenities, others will bear the risk or a portion of it for you."

4-2. Emphasis on this program should be further reduced as the federal flood insurance program is implemented to its fullest extent. Therefore, the provisions of the 1974 Federal Relief Act and the 1973 Flood Disaster Prevention Act

should be rigorously enforced. In addition the policy of relief in the form of tax breaks should be re-examined and be applied judiciously.

Finding 5: An adequate institutional framework has not been developed for data gathering and analysis. (II-C, IV-A-B)

Recommendation:

5-1. The International Joint Commission should promote a program of data collection and analyses. Funding to permit this should be provided.

Finding 6: Full use of the latitude allowed in the operation of Plan 1958-D has not been adequate in the prevention of substantial damage to the natural environment and man made facilities on the shoreland of Lake Ontario and the St. Lawrence River. (V-B)

Recommendation:

6-1. Plan 1958-D and the criteria underlying it be continuously re-evaluated in terms of providing additional flexibility to the Plan's operation in order that damages sustained may be reduced.

Finding 7: The current regulation philosophy of the International Joint Commission is to change lake level regulation plans only if: 1) no economic loss to any major interest (shore property, navigation, power) on any lake or its outflow river occurs and 2) the existing Lake Superior and Lake Ontario regulation criteria are satisfied. (VI-A)

Recommendations:

7-1. This philosophy should be re-examined. An alternative may be that lake level regulation should be analyzed with the objective of maximizing net benefits of the plan of regulation. For equity purposes this would require a compensation machanism whereby those who receive benefits from the change in regulation compensate those who suffer damages due to the change.

7-2. Analysis should be undertaken to determine the net impact that criteria differing from the existing would have on lake level regulation.

Finding 8: Public funds are restricted in their use for providing structural protection to private property. (VI-B)

Recommendation:

8-1. Restrictions on expenditure of public funds should remain. Additional study should be undertaken to evaluate the social costs and benefits of alternatives to structural protection. These alternatives should include, but not be limited to, purchase of hazardous areas and/or development easements on such areas by governmental agencies, relocation of existing development and flood insurance. From this analysis recommendations should be made relative to New York State's and the federal government's policy of expenditure of public funds for the protection of private property versus alternative flood plain management measures.

Finding 9: Criterion (k) of the Plan of Control requires that all possible relief be given to both upstream and downstream riparian owners during periods of high water. Due to the conflicting goals of these two groups this is not possible. (VI-A-4)

Recommendation:

9-1. The criteria underlying Plan of Control 1958-D be re-examined with particular emphasis on Criterion k to determine if the Plan, as designed, can be given greater capability to effectively manage high water levels.

2. Physical Works

Finding 1: Developed areas are dependent upon structural protective devices to reduce damages caused by high water levels. However many areas throughout the New York State portion of Lake Ontario do not lend themselves to such protection as was evidenced by the economic evaluation of Operation Foresight projects. (VI-B)

Recommendation:

1-1. Efforts should be continued to provide protection through the construction of structural devices in those areas currently developed if they qualify for such protection under existing criteria. Use of this technique in the future should be de-emphasized as greater emphasis is placed on flood plain management techniques.

Finding 2: Riparian protection utilizing structural devices influences the quality of the environment, and may result in unanticipated negative impacts on the natural resource base of Lake Ontario and the St. Lawrence River. Individual efforts to protect small sections of shoreline

from damages caused by high water levels are generally not effective, and may cause additional damages to contiguous property. (V-A-2 + B, VI-B)

Recommendation:

2-1. Analysis of construction of shoreland protective structures must be undertaken to determine if these structures singularly or cumulatively affect the natural environment by stabilizing material that otherwise would aid replenishment of beaches; by draining marshes, disrupting wildlife habitats and breaking the food chain of valued species; and blocking river mouths with sediments from shoreline currents altered by shoreline protection structures.

2-2. Efforts should be made to ensure a coordinated approach to construction of shore protection devices in order to minimize the damages incurred on contingent properties and to ensure that maximum benefits are derived from such construction expenditures.

2-3. The Department of Environmental Conservation and the U. S. Army, Corps of Engineers should assess their project review procedures to determine if damages to contiguous property and possible cumulative effect of many small projects in an area are given adequate consideration in project review.

3. Data/Research

Finding 1: Protection of the natural environment (sand dunes, beaches, bluffs, etc.) of Lake Ontario and the St. Lawrence River is dependent upon regulation of the level of Lake Ontario. (V-A-1 + B-2)

Recommendation:

1-1. Additional efforts must be undertaken to derive a plan of regulation that will provide adequate protection for the natural environment of Lake Ontario and the St. Lawrence River. Such an effort should include, but not be limited to, the following:

a. Continued re-evaluation of Plan 1958-D in light of the high supplies of water experienced in the 1970's and low supplies of the mid 1960's.

b. Continued examination of the criteria upon which Plan 1958-D is based to determine if they should be reformulated in light of man's activities or natural events

during the time since they were developed.

c. Development of a plan of regulation that incorporates lake level forecasts as an intregal part of the regulatory procedure.

Finding 2: Current procedures for regulation of Lake Ontario do not require forecasts of lake levels based on meterologic and hydrologic data. (II-C)

Recommendation:

2-1. Regulation procedures be revised to incorporate lake level forecasts as an input to the lake level regulation decision model. These forecasts should be derived utilizing available hydrologic and meteorologic data.

Finding 3: With present techniques of meteorologic and hence hydrologic forecasting the ability to accurately predict long range water supplies to the lakes is limited. However, improved procedures for the collection of hydrologic and meteorologic data which define water supplies to the Great Lakes would contribute significantly to improved regulation decisions. (II-B + C)

Recommendation:

3-1. Efforts should be made to improve the collection, transmittal and analysis of meteorologic and hydrologic data in order to improve the forecast of long range water supplies to the lake.

3-2. The conversion of the United States portion of the lake level gauge system to a semi-automatic system should be accelerated and, if required for improved forecasting, expanded to include additional gauges. Efforts should be made through the International Joint Commission to persuade our Canadian partners similarly to expand their gauge system as required for improved forecasting.

Finding 4: Evaluation of benefits and costs of tradeoffs among varied groups impacted by changes in water levels of Lake Ontario and the St. Lawrence River is not possible due to the lack of adequate data and due to limitations of existing institutional arrangements. (IV-B, VI-A-4)

Recommendations:

4-1. Stage-damage relationships for Lake Ontario and the St. Lawrence River should be developed and kept current.

4-2. Studies should be undertaken to determine the economic consequences of both changes in navigation channel depth and length of navigation season. This should include not only costs to shipping but also the economic affects to those sectors of the economy dependent on shipping.

4-3. Additional studies should be undertaken to determine the impact on fish and wildlife, recreation, environmental factors and wetlands due to water level changes.

4-4. Studies should be undertaken to determine the economic consequences of flow changes for power generation. This would include a determination of costs of providing comparable power by alternative fuels.

Finding 5: The U. S. Army, Corps of Engineers was restricted by its budget in publishing data gathered in their recently completed National Shoreline Inventory Study. (III-B)

Recommendation:

5-1. Adequate funding should be made available to allow publication of this data.

Table 1. Level of Government Holding Primary Responsibility for Carrying Out Recommendations

Level of Government	Recommendations[a]														
	Institutions														
	1-1	1-2	2-1	3-1	3-2	4-1	4-2	5-1	6-1	7-1	7-2	8-1	9-1		
Federal	x	x	x	x		x	x	x	x			x			
State	x	x			x							x			
Regional	x	x										x			
Local	x											x			
International			x	x				x	x	x	x		x		
	Physical Works					**Data/Research**									
	1-1	2-1	2-2	2-3		1-1	2-1	3-1	3-2	4-1	4-2	4-3	4-4	5-1	
Federal	x	x	x	x		x	x	x	x	x	x	x	x	x	
State	x	x	x	x								x	x		
Regional			x												
Local			x												
International						x	x			x	x	x			

[a]The recommendation numbers refer to those listed in I, Findings and Recommendations, of this report.

CHAPTER II

Great Lakes System

A. Description

The Great Lakes System consists of five connected drainage basins. The outflow from each lake is discharged into the next lake downstream with the outflow of Lake Ontario, the last lake in the chain, discharged into the St. Lawrence River. In general the drainage of the basin is from west toward the east. The maximum dimensions of the Great Lakes Basin are approximately 740 miles, measured from north to south, and 940 miles, measured from east to west (see Figure 1).

The area of specific concern in this report is the drainage basins of Lake Ontario and the St. Lawrence River. Following is a brief description of this portion of the Great Lakes System.

Lake Ontario's surface is about 245 feet higher than Father Point, Quebec, which marks the point of the river's transition into the Gulf of St. Lawrence and is considered to be essentially at sea level. From Lake Ontario downstream 68 miles through the Thousand Islands section to 4 miles east of Ogdensburg, New York, the drop in the St. Lawrence River is about 1 foot (see Figures 2 and 3). In the next 47 miles through the International Rapids section the drop is about 92 feet. The International Rapids section extends to the International Border at the entrance of Lake Saint Francis from the South Cornwall Channel. Beyond this point the St. Lawrence River flows entirely within the border of Canada. In the next 72 miles to Montreal Harbour the River falls another 132 feet. In the 340 miles from Montreal Harbour to Father Point the fall is about 20 feet.

Lake Ontario is the smallest of the five Great Lakes (see Table 2). It is approximately 7,600 square miles in surface area and drains a watershed of approximately 27,200 square miles. Lake Ontario surface water is about 245 feet above sea level. It is approximately 804 feet deep at its deepest point. This places the Lake bottom at this point 561 feet below sea level which is lower than the bottom of any other lake except Lake Superior. The Lake has a long east-west axis which is approximately 200 miles. North to south the Lake is approximately 53 miles. Table 3 provides data on Lake Ontario.

Table 2. Great Lakes Physical and Hydrological Data

Description	Lake Superior	Lake Michigan	Lake Huron	Lake St. Clair	Lake Erie	Lake Ontario
Outlet river or channel	St. Mary's River	Str. of Mackinac	St. Clair River	Detroit River	Niagara River	St. Lawrence River
Length in Miles	70	--	27	32	37	502
Recorded Outflows[a]						
Maximum	127,000	245,000[b]		c	265,000[b]	350,000[b]
Minimum	40,900	99,000			116,000	154,000
Average	75,400	188,200			202,600	240,300
Monthly Elevation of Lake in feet[d] IGLD (1955)						
Aver. (1860-1971)	600.39	578.69[e]	578.69[e]	573.06[f]	570.39	244.77
Maximum	602.06	581.94	581.94	575.70	572.76	248.06
Minimim	598.23	575.35	575.35	569.86	567.49	241.45
Aver. winter low to summer high	1.1	1.1	1.1	1.6	1.5	1.9
Max. winter low to summer high	1.9	2.2	2.2	3.3	2.7	3.5
Min. winter low to summer high	0.4	0.1	0.1	0.9	0.5	0.7
Annual Precipitation in inches (1900-1971)						
Aver. on basin (land & water)	30	31	31	c	34	34
Aver. on lake surface	30	30	31	c	34	33

Table 2. Great Lakes Physical and Hydrological Data (continued)

Description	Lake Superior	Lake Michigan	Lake Huron	Lake St. Clair	Lake Erie	Lake Ontario
Approx. Aver.[g] Annual Evaporation from Lake Surface (in.)	22	26	26	c	36	25
Aver. Annual Evaporation as a Percentage of Average Annual Precipitation on Lake Surface	69	79	79	c	100	74

[a]Data from Regulation of Great Lakes Water Levels, Report to the International Joint Commission by the International Great Lakes Level Board, December 7, 1973, page 12.
[b]Maximums established in 1973.
[c]Data not available.
[d]Lake elevations are as recorded at Marquette (L. Superior), Harbor Beach (L. Michigan-Huron), Grosse Pointe Shores (L. St. Clair), Cleveland (L. Erie) and Oswego (L. Ontario). Recorded elevations are affected by man-made changes such as: regulation of outflows from Lake Superior (1921) and Lake Ontario (1960); diversions of water from Hudson Bay basin into Lake Superior (1939) and from Lake Michigan basin into Mississippi basin at Chicago (before 1860); and regiment changes in the natural outlet channels from the lakes throughout the period of record.
[e]The Straits of Mackinac between Lakes Michigan and Huron are so wide and deep that the difference in the monthly mean levels of these two lakes is not measurable.
[f]Lake St. Clair elevations are available only for the period 1898 to date.
[g]Based on data for the period October 1950 - September 1960.
Sources: Great Lakes Shoreline Damage: Causes and Protective Measures, May, 1972, U.S. Corps of Engineers, North Central Division, General Information Pamphlet.
Regulation of Great Lakes Water Levels, Report to the International Joint Commission by the International Great Lakes Levels Board, December, 1973.

Table 3. Lake Ontario--Physical and Lake Level Data

Low water datum (LWD):	74.0 m	242.8 ft
Length:	311 km	193 mi
Breadth:	85 km	53 mi
Shoreline length:	1,168 km	726 mi
Total surface area:	19,000 km^2	7,340 mi^2
Surface area in U.S.	8,960 km^2	3,460 mi^2
Volume at LWD:	1,637 km^3	393 mi^3
Average depth below LWD:	86 m	283 ft
Maximum depth below LWD:	245 m	802 ft
Average surface elevation (IGLD):	74.65 m	244.77 ft
Maximum surface elevation (IGLD):	75.66 m	248.06 ft
Minimum surface elevation (IGLD):	73.64 m	241.45 ft

Source: Great Lakes Basin Framework Study, Great Lakes Basin Commission (draft report).

The Lake Ontario Basin is a lowland bordered on the north by an escarpment of the Canadian Shield, on the east by the Adirondack Mountains, on the south by the Appalachian Plateau and on the west by the Niagran Escarpment. The lake bottom slopes generally southwardly from the north shore, across more than two thirds of the lake. Then the bottom formation rises abruptly to the south shore.

B. Hydrology

Changes in the level of each lake depend upon the difference between their inflow and their outflow. Although inflows change constantly in the shortrun and through seasonal cycles due to changes in supplies resulting from precipitation, the Great Lakes - St. Lawrence system has a remarkably steady outflow in comparison with the range of flows observed in other large drainage basins of the world. This is due to the vast water surface area of the Great Lakes and their inherent ability to account for enormous changes in the quantity of water in storage with little effect on surface elevations. Table 2 reflects the

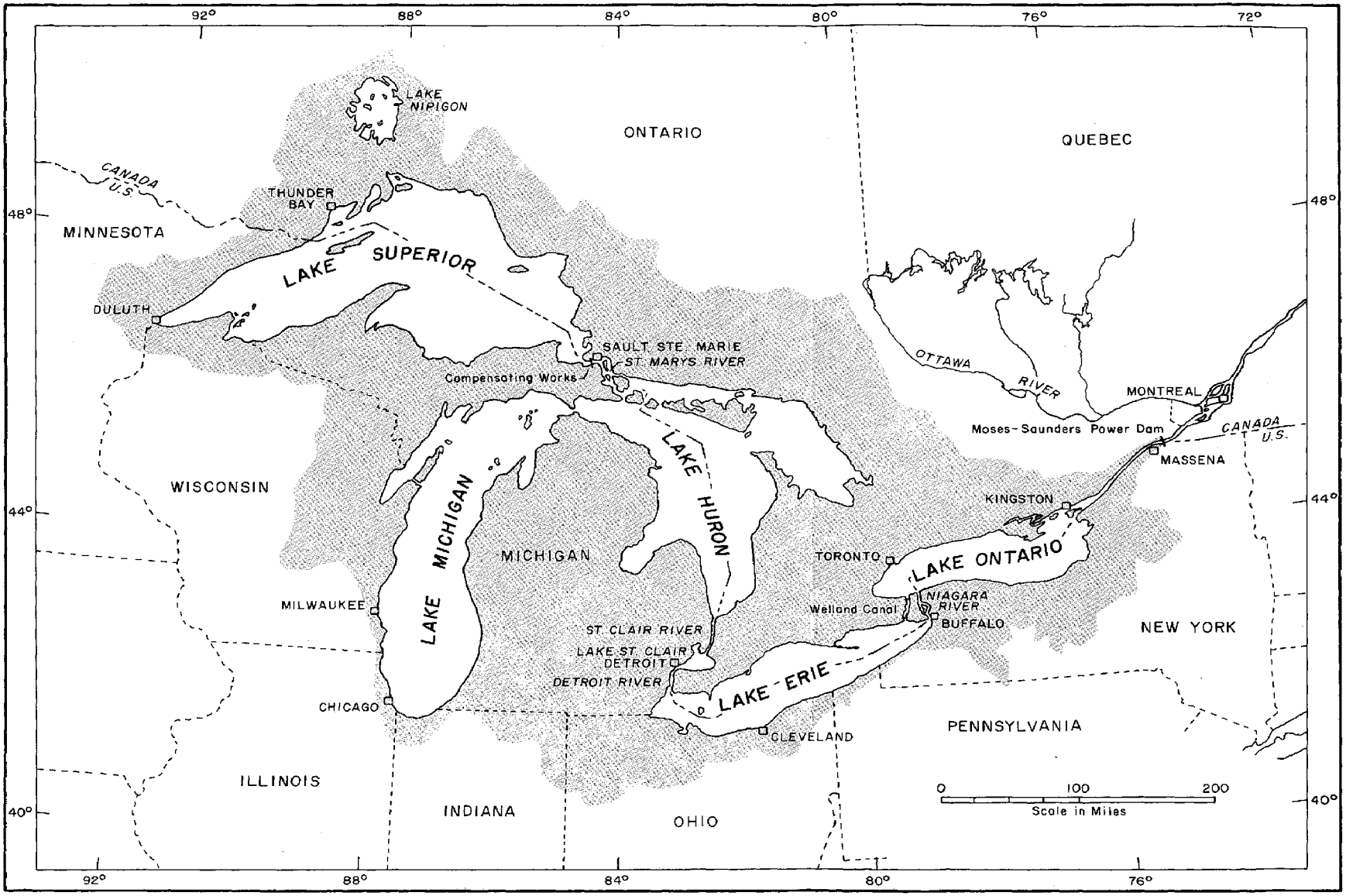


Figure 1. Great Lakes - St. Lawrence River Drainage Basin

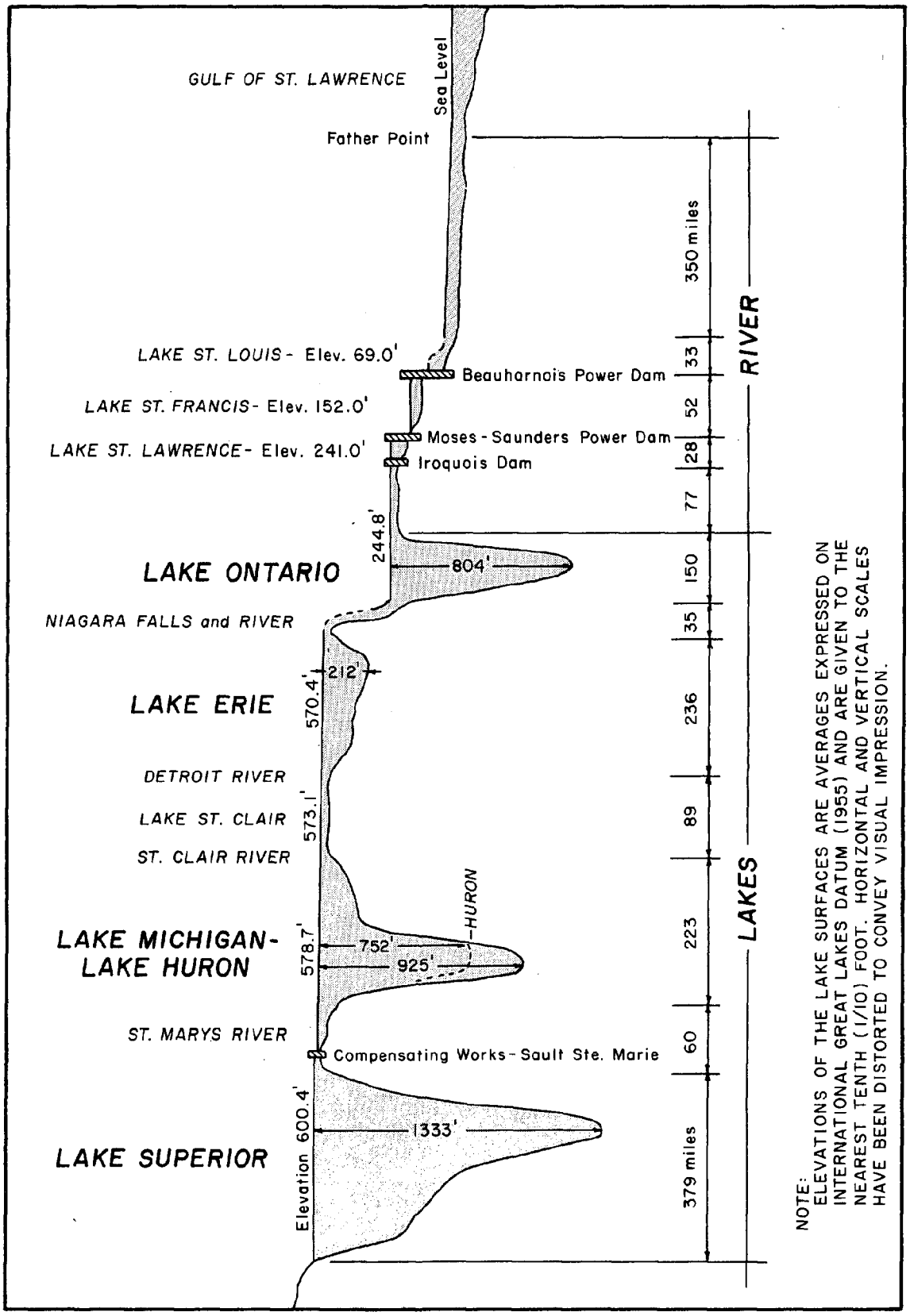


Figure 2. Profile of the Great Lakes - St. Lawrence River Drainage System

normal and the extreme range in monthly mean water levels for the lakes. The recorded range for Lake Ontario exceeds that for any of the other Lakes.

Maximum flows of the outlet rivers of the Great Lakes is only about 2 to 3 times their minimum over the period of record. For the St. Lawrence River the extremes in flow are 351,000 cubic feet per second (cfs) and 154,000 cfs. The maximum outflow was established in 1973. Prior to construction of the St. Lawrence Seaway control structures the maximum recorded outflow was 318,000 cfs.

1. Lake Levels

Reliable U.S. records of the water levels of all the Great Lakes date from 1860. The Lake Survey Center, National Ocean Survey, National Oceanographic and Atmospheric Administration (prior to 1970, the U.S. Corps of Engineers District Lake Survey) maintains 50 permanent water level gauges on the Great Lakes and along their outflow rivers. Canadian agencies also maintain 33 water level gauges on their portion of the Great Lakes system.

Data from both the Canadian and U.S. gauges are in many instances required for an adequate consideration of Great Lakes problems and the two countries exchange data freely.

The water level records indicate that the entire surface of any one of the Great Lakes is seldom, if ever, completely at rest. From beginning to the end of any period such as a month there may be an appreciable change in the average level of the whole surface of a lake that corresponds to a change in the volume of the water in the lake during the interval.

During any particular short period of time such as a few hours the level at one point in the lake may be considerably above or below the level at another point some distance away. This differential would be caused by an external force, such as wind, acting upon the lake surface. There are usually wind-generated waves of some magnitude at any point on the lakes. Water temperature differentials do not disturb the lake surfaces to a measurable extent. The lake levels recorded at a particular gauge station reflect the combined effect of the various level variations at that station excepting the level fluctuation due to wind-generated waves which have periods of only a fraction of a minute.

The Great Lakes are considered essentially non-tidal because of the fluctuation of their levels due to the gravitational effect of the moon and the sun are relatively quite small.

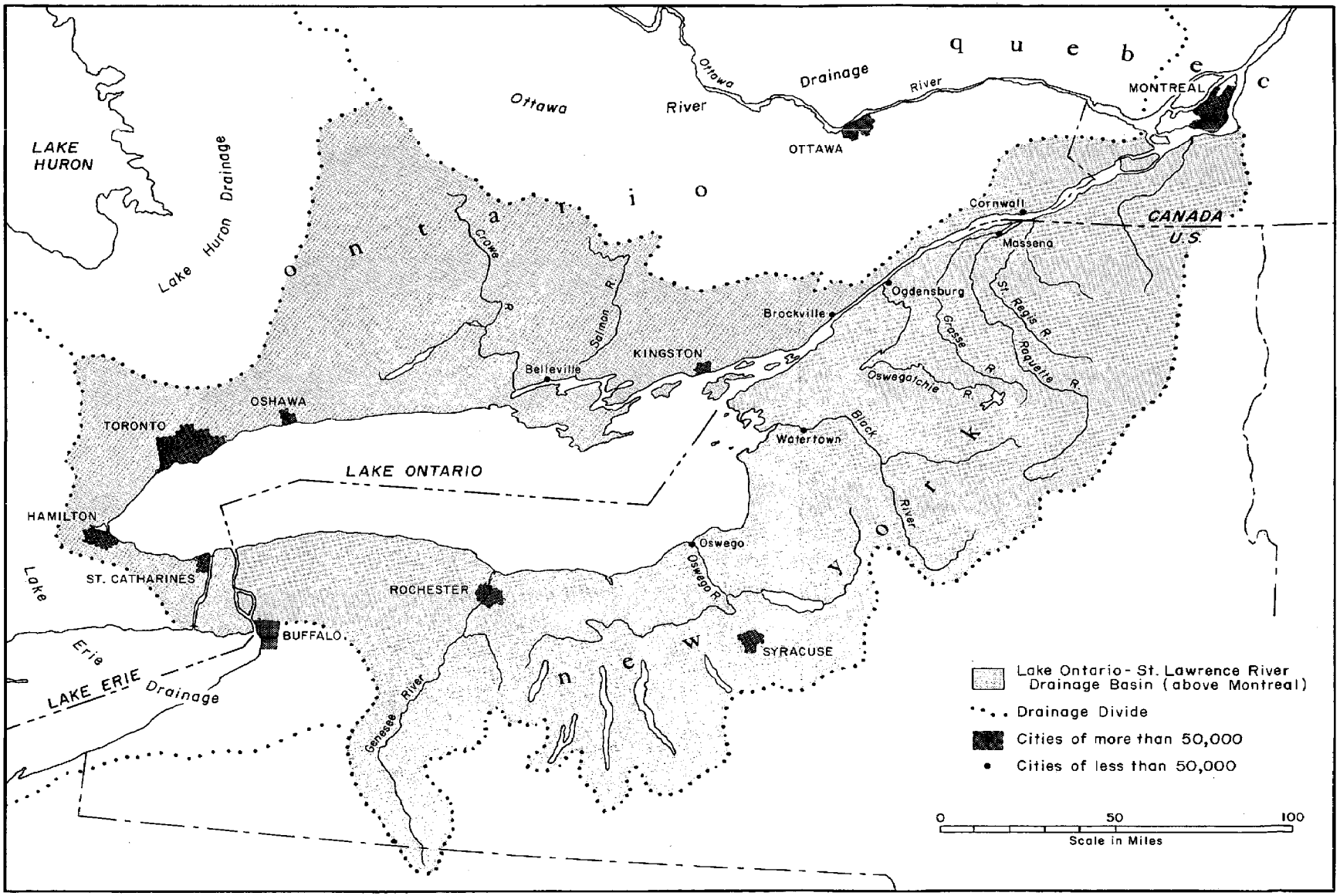


Figure 3. Lake Ontario - St. Lawrence River Drainage Basin

The lake levels most frequently referred to are in terms of the International Great Lakes Datum (IGLD) which gives elevation in feet above the mean water level at Father Point, Quebec. This point is considered mean sea level or zero feet above sea level.

2. Seasonal Lake Level Variations

An annual pattern of seasonal fluctuations in monthly mean lake levels between a high in the summer and a low in the winter occurs on each of the Great Lakes every year almost without exception. The difference between highs and lows as well as the months in which they might occur may differ considerably from year to year. The average and maximum seasonal differences for Lake Ontario exceed those of any of the other Lakes.

The seasonal pattern of natural hydrologic factors is a major cause of these fluctuations. In the spring, runoff increases because of snow melt and low losses of moisture from the land surface by evapotranspiration. Evaporation from lake surface is also slight during the spring. As a result, the lake begins to rise. In the summer, runoff is less because snow melt does not occur and evapotranspiration losses are large. Evaporation from lake surfaces also begins to increase, and as a result lake levels begin to decline.

In the fall evapotranspiration is less and runoff is low, but evaporation from the lake surface is at a maximum. The onset of freezing temperature keeps runoff low. The lake generally reaches its lowest annual elevation level during the winter.

3. Factors Affecting Great Lakes Levels

The factors that affect seasonal and yearly fluctuations of the Great Lakes levels can be separated into two categories: natural and artificial. Changes in the level result from an imbalance between the quantities of water received by the lake and the quantities of water removed from it.

a. Natural - The natural factors causing seasonal and yearly fluctuations of the Great Lakes include precipitation, runoff, evaporation, ice retardation, aquatic growth and crustal disturbances.

The supplies of water to the lakes are changing continually due to the natural variations in the hydrologic factors. Water supplies to the Great Lakes system consist principally of precipitation falling on the lake and runoff from the land areas of the basin. For each of the lower

lakes in the system outflow from the lake above augments the supply to the lake's own basin. Evaporation reduces the total supply reaching any of the lakes (Table 2).

Another factor which affects the level of the Great Lakes is what geologists term crustal movement. For thousands of years there has been a more or less continuous differential uplifting of the earth's crust in the Great Lakes Basin (see Figure 4). Geologists have determined that an uplift of several hundred feet has occurred in some places on the Great Lakes shores since the glacial age. From the lake level records available it appears that the land along the northern and eastern shores of the Great Lakes is rising with respect to the land along the southern and western shore, and also that the crustal movement is such that the land along most of the shores of each of the lakes is subsiding relative to the land at the lake's outlets. This factor becomes especially significant when discussing the St. Lawrence River outflow of Lake Ontario since a rise in the east end will restrict outflow causing inundation of a larger land area with the passage of time. This factor is taken into account in the planning process for the regulation of Lake Ontario.

One other natural factor which affects the lake levels is the retardation of the outflow of outlet rivers by weeds and other aquatic growth. Currently little seems to be known about the effect of the aquatic growth retardation upon the Great Lakes Basin as a whole. However, it is thought that in some cases the effect of weed growth is appreciable. Supportive data relative to this contention is limited.

The flows in the outlet rivers of the lakes during the winter seasons are often retarded materially by ice formation and by ice jamming. These conditions are not predictable for any specific winter, either as to their severity or the exact timing of their occurrence. Average reductions in the outflow rates, for the period January through March, are indicated in Table 4.

b. Artificial or Man Made - The various artificial factors which modify supplies, outflows, and lake levels have existed for many years. These artificial factors are: the diversions of waters to and from the lakes, and changes and outflows through the natural outlet by channel changes and by regulatory works.

Significant artificial factors affecting lake levels are:

1. Long Lake and Ogoki diversions into the Lake Superior Basin;

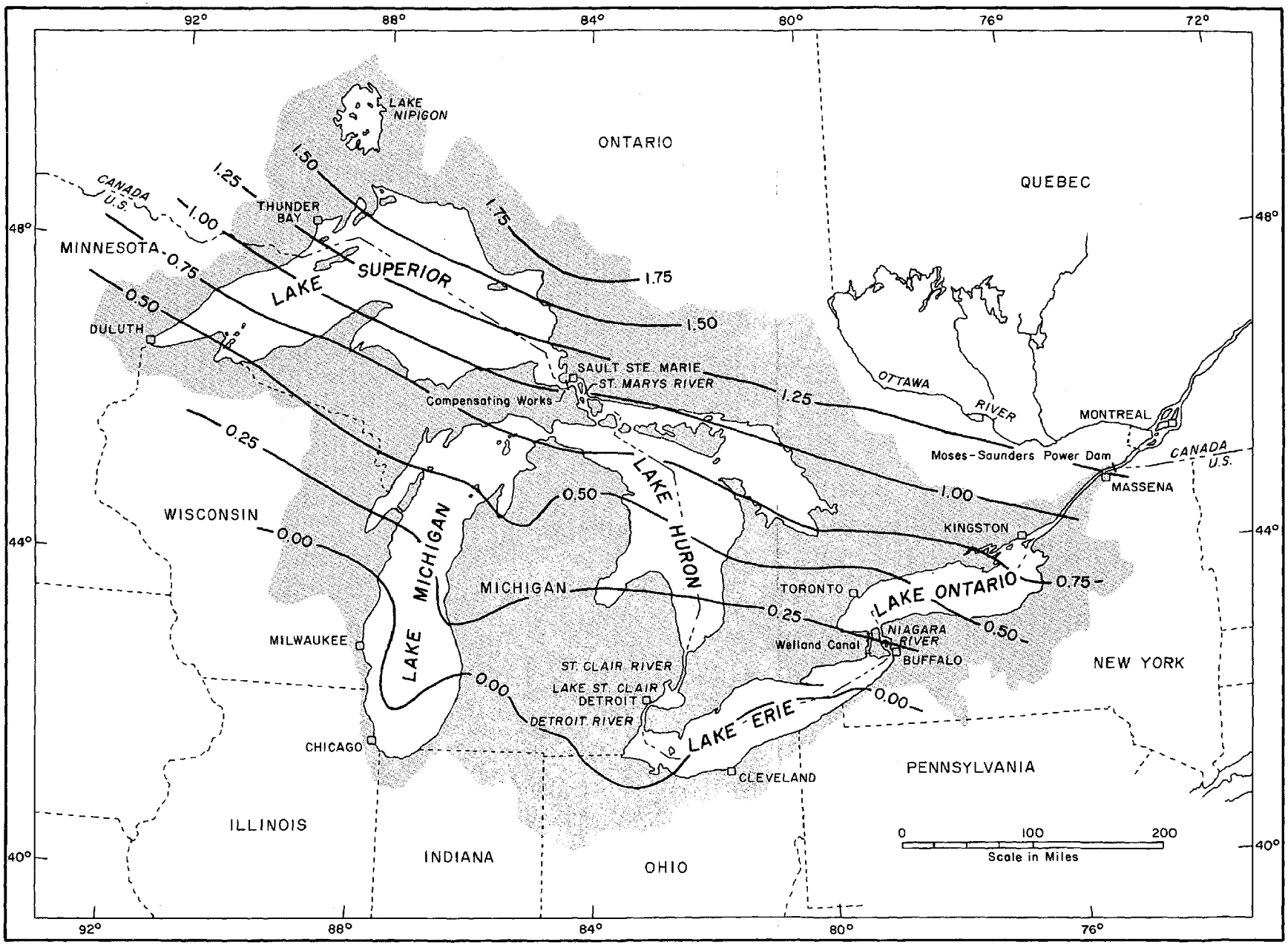


Figure 4. Differential Crustal Movements Within the Great Lakes Basin, Estimated Rates of Upward Movement in Feet Per Century (Source: Regulation of Great Lakes Water Levels, International Great Lakes Levels Board, 1973).

Table 4. Effects of Ice Retardation on Winter Flows (Jan. through Mar., Incl.) in the Great Lakes Connecting Channels and St. Lawrence River

Outlet River	Average Annual Flow (cfs) (1860-1967)	Estimated Average Ice Retardation (cfs)	Percent Retardation
St. Marys	74,500	3,000*	4*
St. Clair	187,000	19,000	10
Detroit	190,000	4,000	2
Niagara	202,000	4,000	2
St. Lawrence	239,000	7,000*	3*

*Prior to regulation.

Source: Regulation of Great Lakes Water Level, Report to the International Joint Commission by the International Great Lakes Levels Board, December, 1973.

2. Regulatory works on the St. Mary's River;
3. Diversions out of Lake Michigan Basin via the Sanitary Canal at Chicago;
4. Channel changes in the St. Claire/Detroit River system;
5. Diversion of Lake Erie via the Welland Canal;
6. Channel changes in the St. Lawrence River; and
7. Regulatory works on the St. Lawrence River.

A detailed discussion of the current artificial factors affecting water levels in the Great Lakes Basin as a whole is not pertinent to this report and therefore only a listing of these factors is provided. For additional information on the total diversion program for the Great Lakes Basin consult Appendix 11, Levels and Flows, of the Great Lakes Basin Framework Study.

The combined effect of all the factors-both artificial and natural-that influence Lake Ontario water levels is shown in Figure 5 which reflects the water levels of Lake Ontario for the past three years. The ten year average monthly mean level and the period of record average monthly mean level is depicted also.

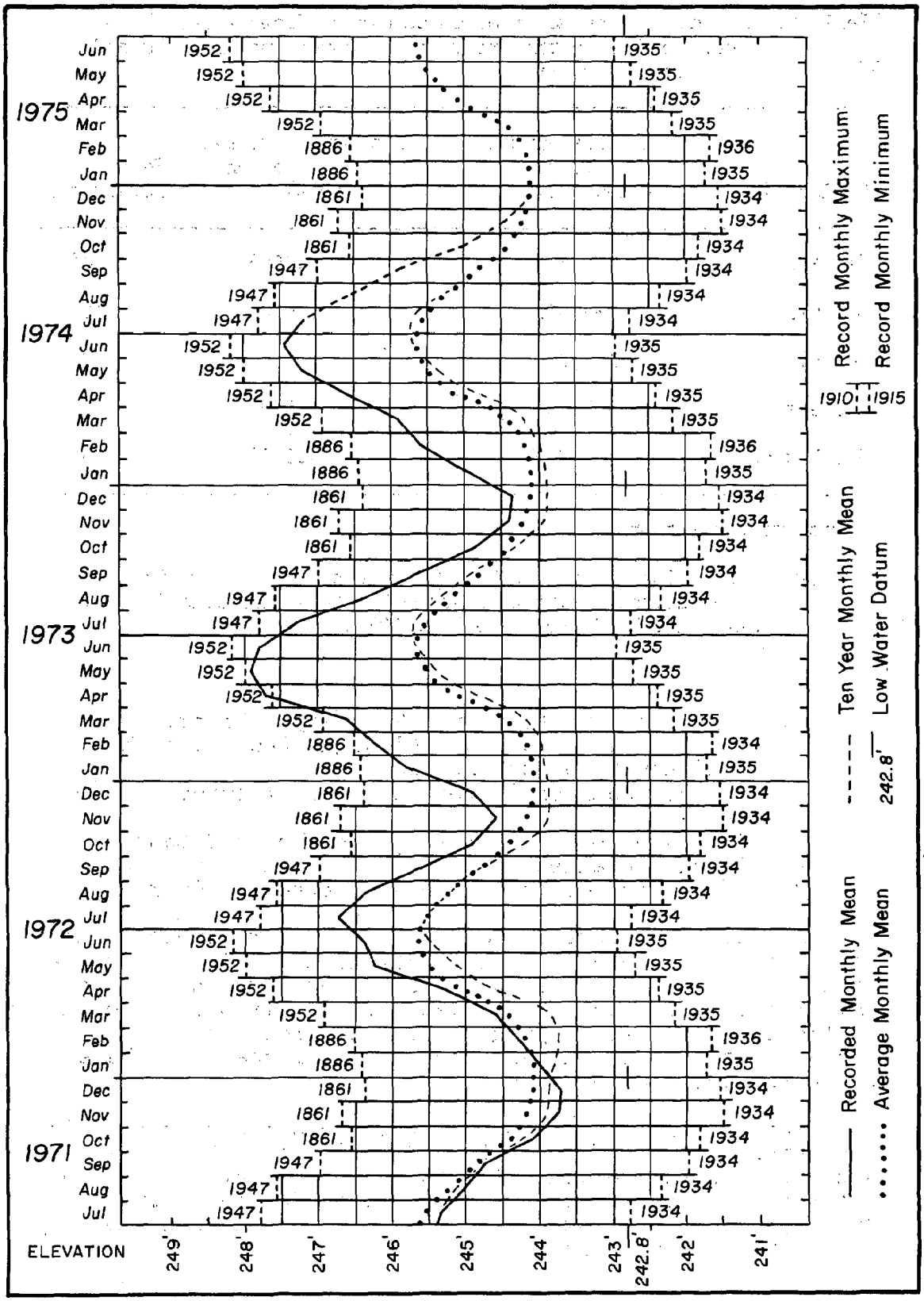


Figure 5. Mean Monthly Water Levels - Lake Ontario (Source: Great Lakes and Connecting Channels Levels and Depths, Dept. of Army, monthly).

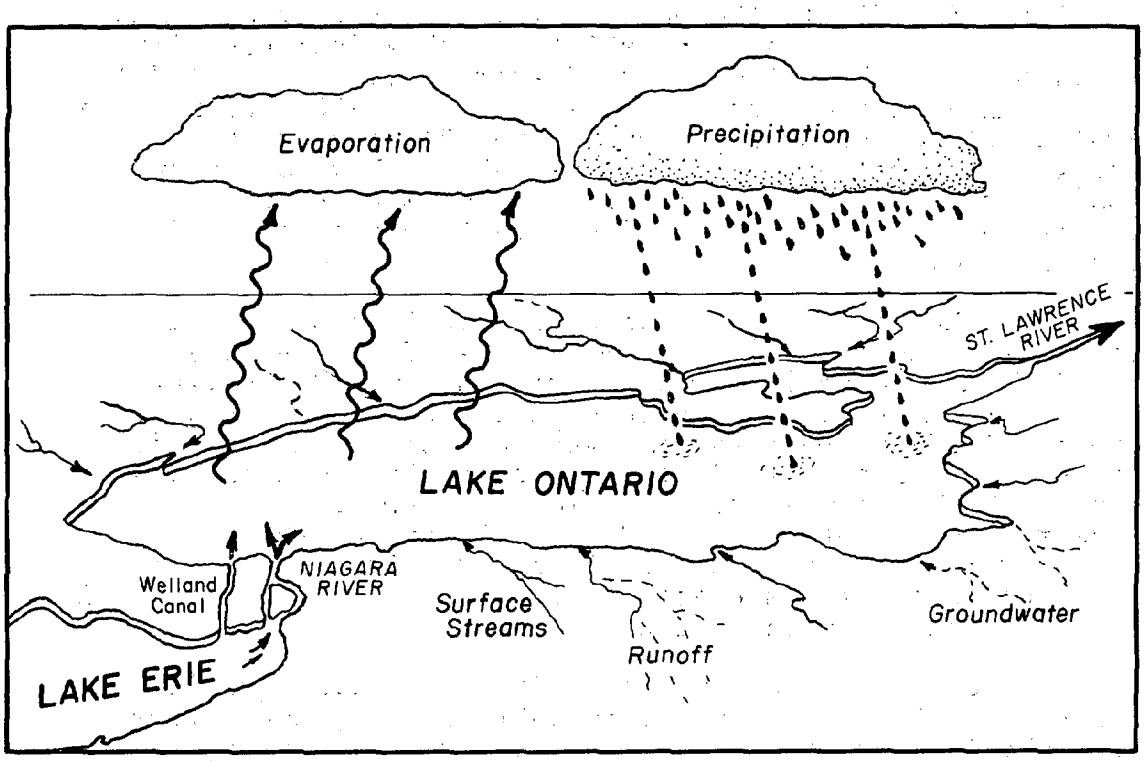


Figure 6. Factors Affecting the Level of Lake Ontario.

4. Background of Current High Water Levels

As discussed in the preceeding section, the water levels of the Great Lakes are influenced by seasonal variations. When the natural factors affecting the lake levels deviate from the norm for a period of time, the Lakes may experience what appears to be a cyclical change in levels. It can be evidenced by either a period of high or low water.

In the period 1964-1966 low water levels were experienced. Over the past three years high water levels have occurred. What were the causes of these high levels?

In a simple analysis of Lake Ontario's level, an examination of the inflow to Lake Ontario from Lake Erie, the amount of precipitation as an indicator of the amount of inflow due to runoff, and the outflow from Lake Ontario measured by the discharge at the control structures at Massena, New York, will be made. An understanding of these figures will partially explain why Lake Ontario reached record or near record levels during the 1972-1974 period. Figure 6 shows in schematic form the various factors influencing lake levels.

Table 5 reflects the amount of inflow received by Lake Ontario from Lake Erie. In 1972 the inflow from Lake Erie was 14 percent above the recorded average (1900-Aug. 1974) and it was 23 percent above average during 1973. During the first eight months of 1974, inflow was 24 percent above the average. At present, Lake Erie as well as Lake Huron and Michigan outflow is uncontrolled. Thus, man has no influence over this factor and its effect on the level of Lake Ontario.

The other major source of inflow to Lake Ontario is runoff from the 27,000 square miles that form the Lake Ontario drainage basin. Data on rainfall yields insight into the relative influence this factor has had on Lake levels. Table 6 provides the average monthly rainfall for the period of record (1900-1973) for the Lake Ontario basin along with the monthly rainfall for the period 1970 to present. The rainfall for 1972 was 27 percent above the yearly average for the period of record 1973 rainfall was 11 percent above the average and through July, 1974 rainfall was 4 percent below the average.

The rainfall data for the entire Great Lakes Basin reflected in Table 7 provides insight into why the inflow from Lake Erie has been and currently is above average. It also suggests that high water levels are not simply a Lake Ontario problem, but are being experienced throughout the entire Great Lakes Basin. Basin precipitation was 14 percent and 7 percent above average during 1972 and 1973, respectively.

The following rule of thumb provides additional insight into why the problem is long term in nature and to the effect that occurrences on the upper Lakes have on Lake Ontario. The rule states that it takes about three and one half years for 80 percent of an effect of a change in outflow from Lake Superior to reach Lake Ontario. In other words, the Great Lakes system is very slow in reacting to major changes in water levels.[1]

Outflows from Lake Ontario are the third major component influencing the lake level. Table 8 provides data on the flow of the St. Lawrence River at Massena, New York. As can be seen, outflows have been above average. It should be noted that since completion of the St. Lawrence Seaway in 1959, these outflows have been controlled.

---

[1]The recently released International Great Lakes Levels Board Study states that it takes two and one half years for 50 percent of the total effect of a supply change to Lakes Michigan-Huron to reach Lake Ontario.

Table 5. Inflow to Lake Ontario From Lake Erie

	Average (1900-Aug. 1974)	Inflows (1,000 cfs) 1972	1973	1974
Jan.	190.5	215	244	233
% of Aver.		(113)[a]	(128)	(122)
Feb.	186.1	205	236	237
% of Aver.		(110)	(127)	(127)
March	191.0	217	250	250
% of Aver.		(114)	(131)	(131)
April	201.2	222	263	264
% of Aver.		(110)	(131)	(131)
May	212.0	234	262	265
% of Aver.		(110)	(124)	(125)
June	213.8	236	265	259
% of Aver.		(110)	(124)	(121)
July	210.2	236	259	250
% of Aver.		(112)	(123)	(119)
August	206.3	232	249	240
% of Aver.		(112)	(121)	(116)
September	201.5	228	240	
% of Aver.		(113)	(119)	
October	198.1	230	232	
% of Aver.		(116)	(117)	
November	198.1	236	234	
% of Aver.		(119)	(118)	
December	197.4	246	233	
% of Aver.		(125)	(118)	
Average for Year	200.5	228.1	247.3	249.8
% of Aver.		(114)	(123)	(124)

[a]( )Indicates inflow in excess of average.

Source: Adapted from data provided by Corps of Engineers, Buffalo District.

Table 6. Monthly and Average Rainfall - Lake Ontario Drainage Basin

	Average (1900-1973)	YEAR 1970	1971	1972	1973	1974
January	2.66	1.69	2.11	2.23	2.03	2.30
% of Aver.		64	79	84	76	86
Febraury	2.42	2.29	4.17	3.36	2.07	1.71
% of Aver.		95	(172)[a]	139	86	71
March	2.63	2.06	2.53	3.29	3.62	2.93
% of Aver.		78	96	(125)	(138)	(111)
April	2.80	2.79	1.54	2.55	3.98	2.48
% of Aver.		99	55	91	(142)	89
May	3.03	3.06	3.16	6.05	3.23	2.97
% of Aver.		(101)	63	(125)	(127)	(133)
June	3.02	3.03	3.16	6.05	3.23	2.97
% of Aver.		(100)	(105)	(200)	(107)	98
July	3.15	4.18	3.62	3.19	2.43	2.69
% of Aver.		(133)	(115)	(101)	77	85
August	2.97	2.97	3.43	3.88	1.78	
% of Aver.		(100)	(115)	(131)	60	
September	2.97	3.61	2.77	3.21	3.00	
% of Aver.		(122)	93	(108)	(101)	
October	2.95	3.57	1.90	3.48	3.73	
% of Aver.		(121)	64	(118)	(126)	
November	2.95	3.52	1.89	4.15	3.75	
% of Aver.		(119)	64	(141)	(127)	
December	2.80	3.65	3.62	4.50	4.69	
% of Aver.		(130)	(129)	(161)	(168)	
Annual	34.35	36.42	32.66	43.67	38.16	(Jan-July)
% of Aver.		(106)	95	(127)	(111)	96

[a]( ) Indicates rainfall in excess of average.

Source: Adapted from data provided by Corps of Engineers, Buffalo District.

Table 7. Monthly and Average Rainfall-Great Lakes Drainage Basin

	Average (1900-1973)	1970	1971	1972	1973	1974
January	2.11	1.74	2.22[a]	2.31	1.70	1.90
% of Aver.		82	105	109	81	90
February	1.79	1.16	2.90	1.89	1.36	1.26
% of Aver.		65	162	106	76	70
March	2.13	1.76	2.01	2.82	2.97	1.93
% of Aver.		83	94	132	139	91
April	2.48	2.53	1.26	2.35	2.68	2.41
% of Aver.		102	51	95	108	97
May	2.96	3.96	2.74	2.61	4.26	3.03
% of Aver..		134	93	88	144	102
June	3.17	2.73	2.84	3.27	3.79	3.15
% of Aver.		86	90	103	120	99
July	3.07	4.31	3.22	3.75	3.11	2.20
% of Aver.		140	105	122	101	71
August	3.00	1.86	2.72	4.56	2.99	
% of Aver.		62	91	152	99	
September	3.28	5.07	2.94	3.93	2.55	
% of Aver.		155	90	120	78	
October	2.73	3.75	2.36	2.50	2.98	
% of Aver.		137	86	92	109	
November	2.63	2.87	2.63	2.51	2.69	
% of Aver.		109	100	95	102	
December	2.26	2.51	3.59	3.47	2.79	
% of Aver.		111	159	154	123	
Annual	31.61	34.25	31.45	35.98	33.87	(Jan-July)
% of Aver.		108	99	114	107	89

[a] (__) Indicates rainfall in excess of average

Source: Adapted from data provided by Corps of Engineers, Buffalo District.

Table 8. Outflows From Lake Ontario Measured at Ogdensburg, New York[a]

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Aver.
						Outflow In 1000 cfs							
1950	220	225	231	259	262	263	257	249	240	235	234	240	244
1951	243	231	263	287	297	294	294	279	270	257	253	254	269
1952	258	266	277	297	305	308	299	286	275	265	251	254	279
1953	254	257	259	273	282	286	278	267	259	245	237	239	261
1954	227	232	254	267	285	282	272	261	254	253	254	256	258
1955	260	246	267	289	294	287	276	265	256	254	258	249	267
1956	238	234	238	257	276	282	274	265	260	247	240	236	254
1957	230	229	234	241	245	247	248	242	234	224	218	214	234
1958	219	212	213	230	229	230	226	221	217	212	204	205	218
-- -- -- -- -- -- -- -- -- --						--Outflow Regulated By Moses-Saunders Power Facility--							
1959	169	180	192	234	250	250	243	225	213	203	204	208	214
1960	207	211	221	241	262	279	274	261	233	203	207	210	234
1961	210	212	208	218	249	278	266	252	246	231	216	214	233
1962	210	207	204	190	195	211	214	216	215	210	207	210	208

Table 8. Outflows From Lake Ontario Measured at Ogdensburg, New York (Continued)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Aver.
1963	209	207	196	189	188	206	214	217	212	212	205	210	205
1964	211	206	193	179	184	196	201	207	207	206	200	193	198
1965	183	182	180	184	177	189	201	206	203	203	210	227	195
1966	222	222	234	234	212	212	219	220	221	216	212	217	220
1967	219	228	215	212	219	218	226	233	232	249	277	281	234
1968	241	249	237	262	246	237	253	262	270	262	254	251	252
1969	235	253	255	264	276	291	297	295	277	255	248	243	266
1970	228	235	235	237	249	249	256	265	258	263	265	259	250
1971	236	248	263	271	285	273	261	259	263	259	247	235	258
1972	222	230	254	273	291	300	310	310	310	302	293	270	281
1973	252	279	299	325	337	350	350	323	317	___	___	___	___
Aver. (1950-1973)	225	228	234	246	254	259	259	254	248	238	235	234	241

[a] After the construction of the Power Project the gauge location changed to Massena, New York.

Source: Adapted From Data Provided by U.S. Army Corps of Engineers, Buffalo District.

Prior to development of the Seaway the record discharge at Ogdensburg was 318,000 cfs. A flow of 351,000 cfs was recorded on July 11, 21 and August 3, 1974. This is currently the discharge of record at Cornwall-Massena.

In summary, the current situation has been caused by prolonged, above average precipitation within the entire Great Lakes Basin. Man has responded to a degree in an attempt to reduce the levels of Lake Ontario by discharging water at a rate well above the average. However, because of physical and institutional constraints, it has not been possible to prevent the lake from rising, at times, to levels which have resulted in substantial damage to both man-made facilities and the natural environment.

5. Hydrologic Data Collection Systems

Both the United States and Canada operate extensive hydrologic data collection systems. These systems consist of water level gauges on both the streams and lakes of the basin along with rain and snow gauges strategically located throughout the Great Lakes Basin.

Within the United States this monitoring program is carried out by the Lake Survey Center, National Oceanic and Atmospheric Administration. Within Canada the Marine Sciences Directorate, Department of Environment, maintains the hydrologic data collection system. Figure 7 and its accompanying table provide data on Great Lakes water level gauge locations and recorded elevations of each gauge. Figure 8 reflects the locations of climatological stations within the Great Lakes drainage basin while its accompanying table provides data relative to each station.

Currently the Lake Survey and the Army Corps of Engineers are converting the United States portion of the Lake level gauge system to a semi-automatic system. A telemetering system has been established for six key Lake Survey Center water level gauges around Lakes Superior, Huron and Ontario. Plans are underway to install the system for gauges on Lake St. Clair and Lake Erie. Currently the system is operational for gauges at Rochester and Oswego, New York, on Lake Ontario. The Canadian portion of the lake level gauge system has been automated since 1972.

Hydrologic data gathered is disseminated by both governments through several publications. Table 9 lists the major publications, frequency of issue and the type of data available within each.

C. Great Lakes Levels Forecasting

In response to the interest created by the high water experienced in 1951 and 1952, the U.S. Lake Survey began

Table 9. Hydrologic Publications - Great Lakes Data

Name	Publisher	Frequency of Issue	Data Included
Lake Ontario Data	U.S. Army Corps of Engineers	Weekly	Daily Mean Elevation, Daily Outflow and Average Inflow for Week of Lake Ontario; Daily Mean Elevation at Oswego and Kingston.
Monthly Water-Level Bulletin	Dept. of the Environment, Canada	Monthly	Mean for Month, Last Year's Mean for Month, Maximum and Minimum Mean for Month, Mean for Month, Last 10 Years, Mean for Month, all years and Probable Mean for Next Month for Lakes Superior, Huron, Erie and Ontario and Montreal Harbor.
Monthly Bulletin of Lakes Levels	U.S. Dept. of Commerce	Monthly	Recorded Levels for previous years and current year to date and probable levels for next six months compared with long term average, last 10-year average, and extreme levels for Lakes Superior, Michigan-Huron, St. Clair, Erie and Ontario; Water Levels of the Great Lakes in inches above or below the plans of reference of the navigation charts; connecting channels water levels and depths.

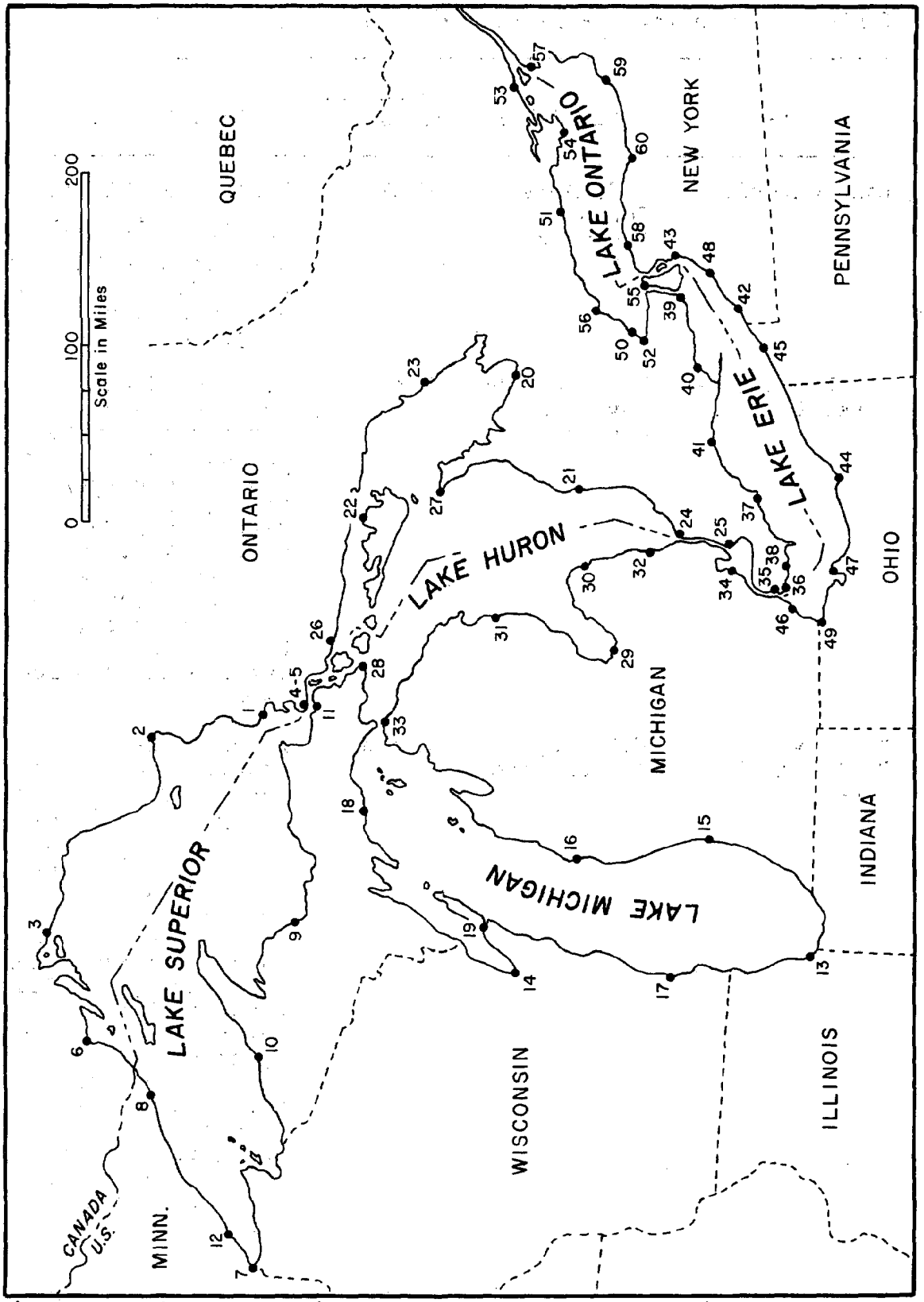


Figure 7 and Accompanying Table: Great Lakes Basin Water Level Gauges - Locations and Records.

Gauge Name and Location	Location Number	Established Date	Extremes of Instantaneous Water Level Elevations, IGLD (1955) Maximum	Date	Minimum	Date
LAKE SUPERIOR						
Canada						
Gros Cap	1	1926	603.53	10/16/72	598.00	1/25/68
Michipicoten	2	1915	604.28	6/16/39	598.05	4/13/26
Rossport	3	1967	602.96	6/30/68	598.70	4/23/70
Sault Ste. Marie Lock (Above)	4	1908	604.09	11/12/42	596.48	5/23/25
Sault Ste. Marie Lock (Below)	5	1908	584.83	12/17/51	575.78	11/23/63
Thunder Bay	6	1907	603.17	7/21/52	597.93	3/17/26
United States						
Duluth	7	1901	602.89	8/31/51	598.59	1/10/58
Grand Marais	8	1966	602.59	10/28/68	598.96	3/31/67
Marquette	9	1902	604.06	6/16/39	597.47	7/17/26
Ontonagon	10	1959	603.66	4/17/65	598.69	4/13/64
Point Iroquois	11	1930	604.23	10/31/51	598.48	4/21/64
Two Harbors	12	1904	603.53	5/5/50	598.61	4/11/48
LAKE MICHIGAN						
United States						
Calumet Harbor	13	1903	583.33	7/23/71	573.33	11/11/40
Green Bay	14	1953	583.62	4/9/73	573.17	11/21/64
Holland	15	1959	581.59	6/17/73	574.80	12/19/64
Ludington	16	1950	581.76	4/16/73	574.76	1/17/65
Milwaukee	17	1903	581.89	7/22/52	574.15	1/23/26
Port Inland	18	1963	581.29	9/16/72	574.19	1/18/65
Sturgeon Bay Canal	19	1945	582.33	5/25/53	574.10	4/14/64
LAKE HURON						
Canada						
Collingwood	20	1906	582.12	6/25/52	573.48	6/26/64
Goderich	21	1910	582.02	5/5/52	574.26	11/28/64
Little Current	22	1959	581.17	11/2/71	573.91	3/5/64
Parry Sound	23	1960	581.07	12/18/72	573.63	3/26/64
Point Edward	24	1927	581.41	5/5/52	573.06	11/28/64
Port Lambton	25	1927	577.51	1/29/52	571.55	11/27/64
Thessalon	26	1926	581.68	7/23/52	574.37	2/12/65
Tobermory	27	1962	581.04	10/16/72	574.30	1/24/65
United States						
De Tour	28	1954	581.28	7/3/73	574.26	3/5/64
Essexville	29	1952	583.57	3/17/73	571.54	3/18/65
Harbor Beach	30	1901	582.01	5/6/52	574.17	1/25/64
Harrisville	31	1963	581.19	8/21/73	574.36	1/9/64
Lakeport	32	1956	582.25	3/17/73	573.82	11/28/64
Mackinaw City	33	1899	582.01	7/22/52	574.45	3/5/65
LAKE ST. CLAIR						
United States						
Grosse Pte. Shores	34	1955	575.51	7/8/69	569.58	1/26/64
LAKE ERIE						
Canada						
Amherstburg	35	1960	575.25	11/14/72	566.21	1/27/65
Bar Point	36	1966	574.87	11/14/72	565.87	1/26/71
Erieau	37	1957	573.49	11/14/72	566.85	11/21/64
Kingsville	38	1962	574.50	11/14/72	564.13	11/21/64
Port Colborne	39	1911	577.69	4/1/29	564.22	3/10/64
Port Dover	40	1958	575.80	10/27/67	565.02	3/10/64
Port Stanley	41	1908	574.17	3/22/55	566.58	3/17/35
United States						
Barcelona	42	1960	574.82	10/27/67	565.08	3/10/64
Buffalo	43	1889	579.09	11/3/55	564.17	3/10/64
Cleveland	44	1903	574.48	6/16/73	565.71	2/4/36
Erie	45	1957	574.85	12/16/72	566.00	3/10/64
Fermi	46	1962	575.85	6/17/73	563.03	2/16/67
Marblehead	47	1959	575.18	11/14/72	564.54	11/21/64
Sturgeon Point	48	1968	576.47	11/1/73	568.70	12/31/69
Toledo	49	1940	576.67	4/9/73	561.47	1/2/42
LAKE ONTARIO						
Canada						
Burlington	50	1970	247.19	7/23/72	242.85	1/25/72
Cobourg	51	1956	247.66	7/2/56	241.26	12/25/64
Hamilton	52	1960	246.45	6/3/69	241.04	2/3/65
Kingston (Portsmouth)	53	1909	248.55	6/6/52	241.01	1/2/65
Point Petre	54	1969	247.21	8/9/72	243.31	1/28/70
Port Weller	55	1929	247.85	5/30/30	241.19	2/3/65
Toronto	56	1906	248.34	6/8/52	240.64	12/26/34
United States						
Cape Vincent	57	1914	248.19	5/11/73	240.93	1/2/65
Olcott	58	1967	248.87	6/22/73	243.26	11/19/69
Oswego	59	1933	248.96	6/6/52	240.94	12/23/34
Rochester	60	1952	248.40	5/28/73	241.38	12/23/64

Source: Great Lakes Basin Framework Study, Appendix No. 11, Levels and Flows, Sept., 1972; Canadian data updated through 1972 from Water Levels, Volume 1 - Inland, Dept. of Environment, Canada, 1972; United States data updated through 1973 by Corps of Engineers, Buffalo District.

Table 9. Hydrologic Publications - Great Lakes Data (Cont.)

Name	Publisher	Frequency of Issue	Data Included
Water Levels of the Great Lakes, Weekly Data Summary	NOAA, Lake Survey Center, Water Levels Branch	Weekly	Projected Water Level for Week; Difference from Stage Recorded Prior Week, Prior Month and Prior Year; Difference from Long-Term, Highest and Lowest Monthly Average of Record.

publishing the Monthly Bulletin of Lake Levels. The first bulletin included a forecast of lake levels that was based upon judgmental consideration of the factors that affect lake levels. Since then, numerous studies have been conducted by the Lake Survey to determine mathematical relationships between these factors and water supplies in order to improve the over-all forecasts.

1. Methodologies

The method now employed by the Detroit District, U.S. Army Corps of Engineers was developed from an analysis of the elements affecting the net basin supply to each of the lakes.[2] The net basin supply is a conceptual hydrological event that can best be described by referring to the classical change of storage equation, which is

$$(1) S = P + R + U - E + I - O \pm D$$

Where:
- S = Change in lake storage;
- P = Precipitation on the lake's surface;
- R = Runoff from the lake's land drainage area;
- U = Groundwater contribution;
- E = Evaporation from the lake's surface;
- I = Inflow from the lake above;
- O = Outflow from the lake through its natural outlet;
- D = Diversion; plus (+) if into lake; minus (-) if out of lake.

[1]This section is adopted from: Forecasting the Levels of the Great Lakes, U.S. Lakes Survey, Misc. Paper 67-2, B. G. DeCooke and E. Megerian, Sept. 1967.

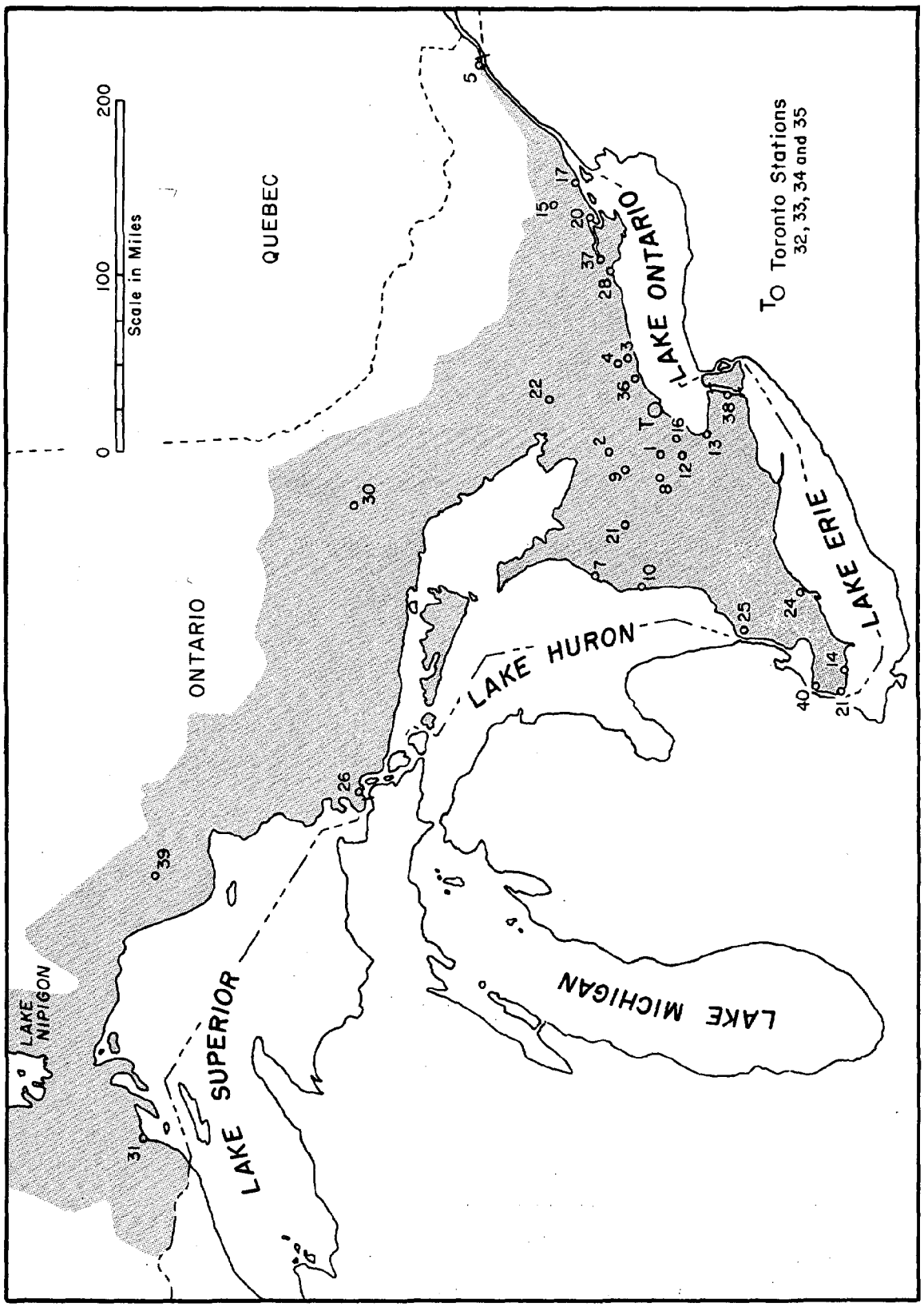


Figure 8 and Accompanying Table: Location of Climatological Stations - Canadian Portion of Great Lakes Basin. (Source: Climatological Station Catalogue - Ontario, 1970)

Location[a] Number	Station Name	Date Station Was Established	Synoptic Report	Hourly Weather	Temperature	Precipitation	Rate of Rainfall	Wind Mileage	Soil Temperature	Evaporation	Sunshine	Radiation	Snow Survey	Agromet
							Canada							
1	Blue Springs Creek IHD	7-66			X	X	X			X				
2	Borden A	9-66	X	X	X	X	X						X	
3	Bowmanville Mostert IHD	6-66			X	X	X			X				
4	Burketon McLaughlin IHD	2-69			X	X	X			X	X			
5	Cornwall Ont Hydro	12-54			X	X	X	X			X			
6	Delhi CDA	6-34			X	X	X	X			X			
7	Douglas Point	10-65			X	X	X	X						
8	Elora Research Station	3-69			X	X	X	X	X		X			X
9	Fergus Shand Dam	10-39			X	X	X	X						
10	Goderich A	11-69		P[b]	X	X	X	X					X	
11	Gore Bay A	7-47	X	X	X	X								
12	Guelph OAC	5-1881			X	X	X	X	X	X	X	X		X
13	Hamilton RBG	4-50			X	X	X	X		X	X			
14	Harrow CDA	4-17			X	X	X		X	X	X			X
15	Hartington IHD	12-67			X	X	X			X				
16	Hornby IHD	7-67			X	X	X			X				
17	Kingston A	10-30	X	X	X	X					X		X	
18	Langton IHD	12-67			X	X	X			X				
19	London A	7-40	X	X	X	X	X				X			
20	Morven IHD	12-67			X	X	X			X	X			
21	Mount Forest	1-1876	X	X	X	X	X				X		X	
22	Muskoka A	7-34	X	X	X	X								
23	North Bay A	1-39	X	X	X	X	X				X		X	
24	Ridgetown	4-1883			X	X	X			X				
25	Sarnia Polymer	9-59			X	X		X			X			
26	Sault Ste Marie A	8-61		X	X	X	X				X			
27	Simcoe	8-61	X	X	X	X	X			X			X	
28	Smithfield CDA	8-49			X	X	X				X			X
29	South Bay Mouth	7-54			X	X		X			X			
30	Sudbury A	1-54	X	X	X	X							X	
31	Thunder Bay A	1-70	X	X	X	X	X				X		X	
32	Toronto	1-1840			X	X	X		X		X	X		
33	Toronto Downsview A	9-59	X	P[b]	X	X	X							
34	Toronto Int A Malton	1-61	X	X	X	X	X							
35	Toronto MET Research Stn Ont	5-65			X	X	X	X	X		X	X	X	
36	Toronto Scarborouth	5-59			X	X						X		
37	Trenton A	4-1883	X	X	X	X	X						X	
38	Vineland Station	1-15			X	X		X	X		X			
39	White River	8-1886	X	X	X	X	X				X			
40	Windsor A	7-40	X	X	X	X	X						X	

[a]Location numbers refer to accompanying Figure.
[b]Indicates that less than 24 hourly observations were taken each day.

The changes in storage, inflow, outflow, and diversion values are determinable directly from reliable records, whereas the lake precipitation, runoff, groundwater contribution, and evaporation cannot be determined directly from presently available data.

The first four terms of the right-hand side of the equation can be combined in a single term called net basin supply (NBS) to the lake. The equation is then written:

$$(2)\quad NBS = S + O - I \pm D$$

The net basin supply represents the volume of water the lake receives from precipitation on its surface and its own land drainage basin, minus the evaporation from the lake surface. The estimation of net basin supply is in fact a complex and uncertain business for many reasons, such as the apparent non-stationary nature of the precipitation process; the non-linear response of the lake basin; and the inadequate knowledge of runoff, underground flow conditions, and evaporation rates.

The Lake Survey develops forecasts for a six month period. The forecast for the first month's NBS of the period is determined using a multiple linear regression model in which precipitation and temperature of current and antecedent months are used as independent variables, with net basin supply as the dependent variable, i.e.

$$(3)\quad NBS = aP + bP_A + cT + dT_A + K$$

Where

NBS = Estimate of average monthly supply to the lake from its own drainage basin (dependent variable) in thousands of cubic feet per second;

P, P_A = Current and antecedent precipitation (independent variables) in inches;

T, T_A = Current and antecedent temperature (independent variables) in degree Fahrenheit;

a, b, c, d = Coefficients of regressions; and

K = Constant of equation.

Twenty-eight years of data were utilized in obtaining these multiple linear regression equations. The recorded net basin supply data, the dependent variable used in the above-mentioned relationship, were computed using the equation (2) relationship.

The method being employed for forecasting the supply used in the determination of the levels for the second through sixth month is based on a time series analysis of the recorded net basin supply.

In the development of the system, it was assumed that net basin supply over a given period is the result of two components: the persistence component and the random component.

The persistent component consists of antecedent net basin supply levels. There are in turn three sub-components of this component. They are the trend, seasonal and cyclical sub-components.

The second component of the net basin supply is the random component. It is dependent on many seemingly chance factors and cannot be reduced to definite rules. At times this component is largely responsible for extreme supply conditions.

In summary, the Detroit District, Corps of Engineers forecast of lake levels for each month of the 6-month forecast for each of the Great Lakes is accomplished by routing through the Great Lakes system the forecasted net basin supplies, as determined by multiple linear regression for the first month (modified by trend), and by trend analysis extension for the second through the six month. The routing employs the current methods of regulation on Lakes Superior and Ontario and the current equations of outflow from Lakes Michigan-Huron and Erie, with adjustments made for average ice retardation during the winter months. By employing the routing system, the effects of the total supplies to each of the lakes of the system of the current lake level and outflow conditions of the lakes upstream are embodied in the forecast.

The forecast employs the services of the U.S. Weather Bureau, which supplies antecedent temperature and precipitation and advance information on its 30-day outlook of temperature and precipitation, and of the Meteorological Service of Canada, which also supplies antecedent precipitation and temperature.

About two years ago the Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration began to develop lake level forecasts utilizing a climatological approach.[2] Long term monthly net basin supplies are the basic input of this forecast methodology. These supplies are then routed through the Great

---

[2]This description was provided by Dr. Frank Quinn, Head, Lake Hydrology Group, GLERL, NOAA in letters dated January 21, 1975 and February 5, 1975.

Lakes hydraulic response model to determine beginning-of-month lake levels for the following six months.

Differences between the two independently derived forecasts described above are then discussed and analyzed by personnel from the two agencies making the forecasts. From these efforts a coordinated six-month lake level forecast is developed. This is published in the Monthly Bulletin of Lake Levels.

2. Appraisal

The predicted lake levels are not a direct input into the Plan of Control for the determination of release rates. They are used, however, to provide guidance and to aid in determining when deviance from the Plan is merited. They are also important in providing information to those individuals who are impacted by the level of the Lake. Since many of these people's decisions are based upon the predicted levels, a reliable estimate is desired.

Table 10 shows the actual level of Lake Ontario by month from January, 1972 to August, 1974. In addition, the levels predicted one and six months prior to the date of the actual reading of the Lake level are shown. These are reflected as plus (+) or minus (-) differences between the predicted and the actual levels.

As can be seen, the predicted levels for the period examined were generally less than the actual. In some cases these differences were significant. For example, the one month predicted level for December, 1972 was .65 feet less than the actual. The six month predicted level for March, 1973, was 2.15 feet less than the actual.

This underprediction is evidenced in Table 10 by the preponderance of minus (-) signs preceeding the differences between actual and predicted levels. Figure 9 depicts the recorded and the predicted levels. Again, the fact that during the period of high water, peaks and troughs were underestimated is reflected. Similarly during periods of low rainfall the methodology utilized will consistently predict levels above those that actually occur.

In summary it appears that the levels predictions are limited in their usefulness because of the limitation of the methodology utilized in deriving them. This methodology appears to provide predictions that consistently deviates from the average less than the actual levels do. This results as the methodology underestimates levels in time of above average rainfall and overestimates them in time of below average rainfall. It appears that efforts to improve this methodology are required in order to provide more reliable forecasts of future lake levels.

Table 10. Differences Between Recorded and Predicted Lake Levels 1972-1974

1972	Actual	Predicted - Actual		1973	Actual	Predicted - Actual		1974	Actual	Predicted - Actual	
		Predicted 1 month In Adv.	Predicted 6 months In Adv.			Predicted 1 month In Adv.	Predicted 6 months In Adv.			Predicted 1 month In Adv.	Predicted 6 months In Adv.
Jan	244.14	-.17	-.30	Jan	246.00	+.05	-1.90	Jan	245.30	-.10	+.25
Feb	244.40	-.25	-.60	Feb	246.40	-.15	-2.10	Feb	245.75	-.05	-.65
March	245.00	-.40	-.70	March	247.15	-.45	-2.15	March	246.20	-.10	-1.50
April	245.80	-.30	-.80	April	247.80	-.25	-1.85	April	246.80	-.30	-.75
May	246.30	-.45	-1.00	May	247.85	+.10	-1.25	May	247.30	-.35	-1.35
June	246.55	-.50	-1.05	June	247.50	+.15	+.20	June	247.25	Same	-1.20
July	246.50	-.55	-1.10	July	246.85	+.35	+.75	July	246.80	+.20	-.50
August	246.05	-.10	-1.10	August	246.00	+.35	-.20	August	246.00	+.15	-.45
Sept	245.20	+.10	-.80	Sept	245.20	+.10	+.60				
Oct	244.70	-.25	-.90	Oct	244.60	-.20	+.65				
Nov	244.75	-.50	-1.10	Nov	244.35	-.15	+.15				
Dec	245.30	-.65	-1.70	Dec	244.60	-.35	+.50				

Source: Adapted from Great Lakes and Connecting Channels Water Levels and Depths, Dept. of Army, Monthly

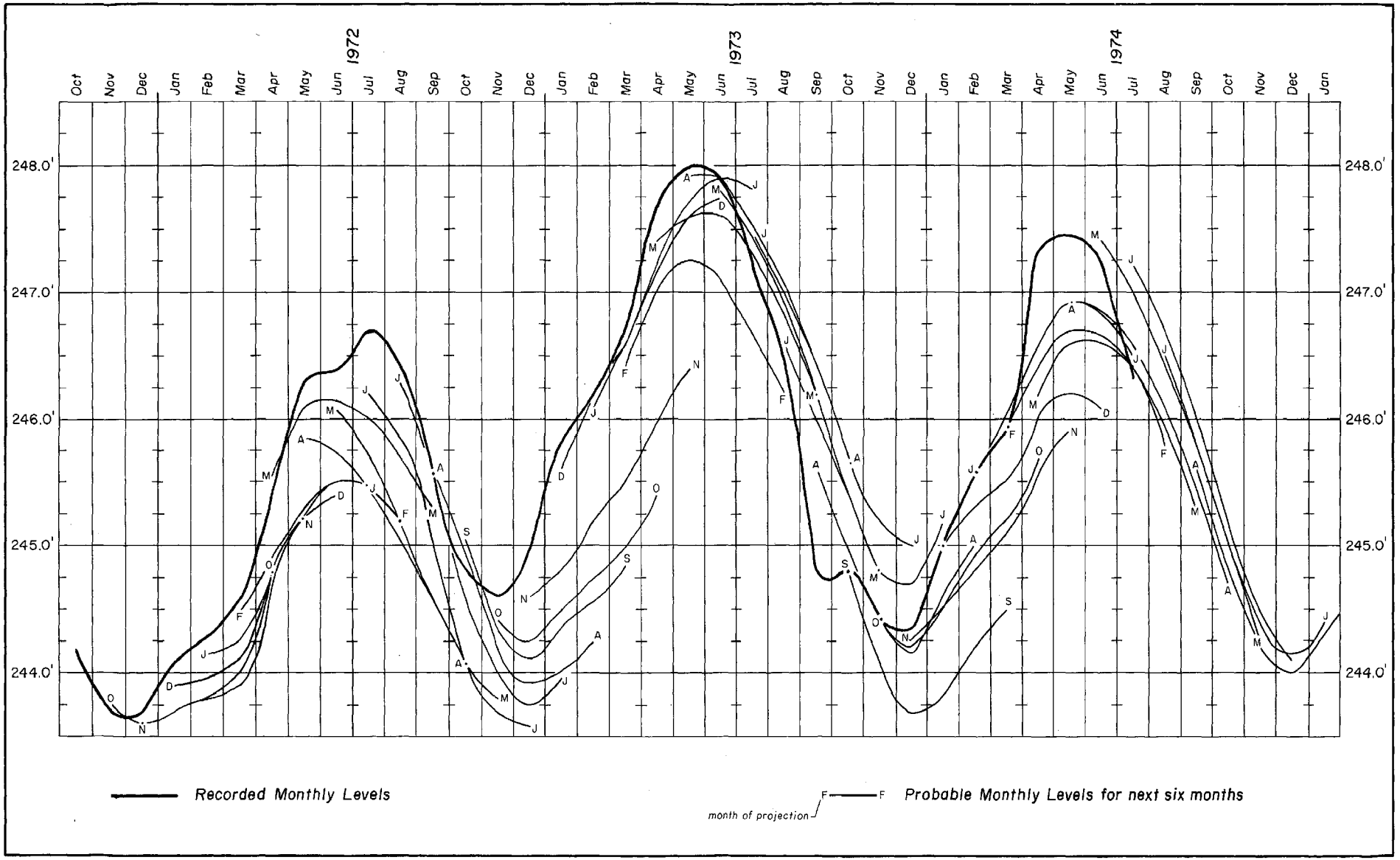


Figure 9. Recorded and Probable Lake Ontario Water Levels. (Source: Adapted from Great Lakes and Connecting Channels Water Levels and Depths, Corps of Engineers).

The following paragraph summarizes the situation relative to forecasting in the Great Lakes Basin.

> ". . . benefits can be obtained from regulation decisions based on a forecast if the forecast is accurate for at least four months into the future. Present knowledge of the future climate over the basin prevents the preparation of such a forecast. However, present knowledge of hydrology permits the assessment of the hydrologic potential of flood or drought on the basin. The principal deterrent to such an assessment is the lack of near real-time data. To provide such data for a basin the size of the Great Lakes is expensive, and tangible benefit is difficult to demonstrate. However, regulation decisions are made at present with only knowledge of current water level and little knowledge of the potential hydrologic response of the basin. Therefore, in order to bring all available information to bear on regulation decision, the study and development of a real-time hydrometeorological network for the Great Lakes basin should be undertaken. Most of the data required are presently collected by existing hydrologic and meterorological networks. Further study of these networks is required to determine their adequacy. The principal items which require development are the collation of data and interchange between countries within a few days of data collection. Such a collection in real time would provide those who must make regulation decisions on the Great Lakes with the response of the basin to various current hydrologic conditions and would improve regulation decision making."[3]

---

[3]Regulation of Great Lakes Water Levels, Appendix A, Hydrology and Hydraulics, International Great Lakes Level Board, December 7, 1973, pp. A-55 to A-56.

CHAPTER III

USES OF LAKE ONTARIO - ST. LAWRENCE RIVER WATER AND ADJACENT LANDS

Uses of Lake Ontario - St. Lawrence River water and adjacent lands are fairly compatible under normal conditions. However, when conditions differ from the norm, conflicts arise, the magnitude of which depends upon the degree to which the normal and experienced conditions differ. Discussed below are the primary uses of these waters and lands along with descriptions of the water level conditions each user would prefer to have maintained.

A. Water Use

Two primary uses of the waters of Lake Ontario and the St. Lawrence River are discussed in detail. These are navigation and power production. The St. Lawrence River has been intensively developed for both uses through efforts resulting from international agreements and cooperation.

1. Navigation

Discussion of navigation is limited to the time frame from the opening of the St. Lawrence Seaway on April 25, 1959 to present. The Seaway was built as a joint venture by the St. Lawrence Seaway Development Corporation of the United States and the St. Lawrence Seaway Authority of Canada. The former was authorized by Public Law 358 passed in 1954 and was charged with the responsibility of developing and managing the United States portion of the Seaway.

Construction took about five years and cost approximately 470 million dollars. These costs were shared by the United States and Canada with the former paying about 25 percent or 130 million dollars and the latter 75 percent or 340 million dollars.

The Seaway provides a channel of a minimum depth of 27 feet from the Gulf of St. Lawrence to Lake Ontario, thus opening the Great Lakes to ocean traffic. Ship size is limited to vessels up to 75 feet in beam and 730 feet in length with drafts 25 feet or less. This limit is due to the size of the locks in the system.

Figure 10 and Tables 11 through 13 portray the amounts and types of cargo and vessels that have passed through the Seaway over the past 10 years. Although subject to fluctuation, the general trend has been upward as far as total tonnage is concerned with an increase occurring in the percentage of total tonnage made up by bulk shipment of cargo.

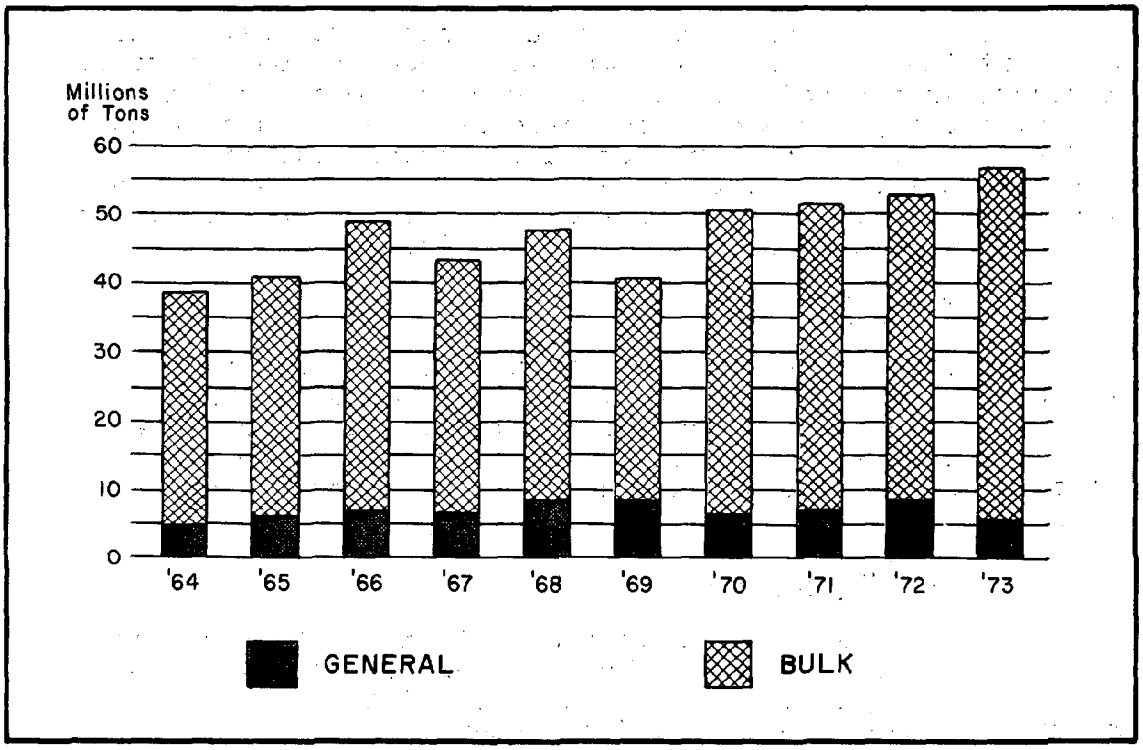


Figure 10. Ten-year Selected Traffic Summary - Montreal to Lake Ontario. (Source: St. Lawrence Seaway Development Corporation, Massena, New York - 1973 Annual Report.)

Shipping interests, in general, are more concerned with the rate of release of waters from Lake Ontario than with its level. However, under occurrences of extreme low water levels, the Lake level becomes of greater concern due to the fact that outflow from the Lake and channel depths in harbors are reduced.

Table 11. Ten-Year Selected Traffic Summary-Montreal to Lake Ontario

	Cargo (in millions of tons)		
	General	Bulk	Total
1964	3.7	35.6	39.3
1965	5.6	37.8	43.4
1966	5.5	43.7	49.2
1967	6.0	38.0	44.0
1968	8.0	40.0	48.0
1969	7.0	34.0	41.0
1970	6.5	44.6	51.1
1971	8.6	44.3	52.9
1972	7.9	45.8	53.7
1973	5.8	51.8	57.6

Source: St. Lawrence Seaway Development Corporation, Massena New York - 1973 Annual Report

In general, a high rate of release at the control structure tends to draw down Lake St. Lawrence until such times as a sufficient steep gradient is established between the water level at the control structure and Lake Ontario as to maintain the outflow from Lake Ontario equal to the Power Dam release rate (see Figures 11 and 12). This reduces the water depths and thus may deny deeper draft vessels adequate water depths to allow transit of this area. The converse is that a low rate of release at the control structure tends to raise Lake St. Lawrence and reduce the gradient between Lake Ontario and the Power Dam. Thus, vessels with deeper drafts are able to transit this area. This decrease in gradient occurs as Lake St. Lawrence fills to capacity when inflows from Lake Ontario exceed outflows through the control structure(s). It should be noted that this is one of the critical areas for navigation since the area covered by Lake St. Lawrence was, prior to the construction of the control structures, a series of rapids known as the International Rapids.

Outflows from the control structures can create problems for navigation under two sets of conditions. In the case of an extreme low level of Lake Ontario, the required minimum

Table 12. 1973 FINAL SELECTED TONNAGE TOTALS
Special Commodities-Montreal-Lake Ontario Section

	1972	1973	Percent (+)or(-)
Bulk Cargo			
Grain			
Wheat	10,681,500	11,417,199	+ 6.9%
Corn	3,642,624	3,922,792	+ 7.7%
Soybean	1,614,608	1,656,316	+ 2.6%
Barley	4,438,979	3,536,135	- 20.3%
Other	1,127,863	2,217,294	+ 96.5%
Grain-Total	21,505,574	22,749,736	+ 5.8%
Iron Ore	12,533,408	15,691,569	+ 25.2%
Coal	269,164	277,667	+ 3.2%
Fuel Oil	3,229,062	3,783,946	+ 17.2%
Other Bulk	8,273,279	9,305,889	+ 12.5%
All Bulk-Total	45,810,487	51,808,807	+ 13.1%
General Cargo			
Iron and Steel	5,333,432	3,723,202	- 30.2%
Automobiles and Trucks	84,471	81,699	- 3.3%
Containers	427,604	299,797	- 29.9%
Other General	2,000,587	1,720,632	- 13.9%
General-Total	7,846,094	5,825,330	- 25.8%
Grand Total	53,656,581	57,634,137	7.4%

Source: St. Lawrence Seaway Development Corporation, Massena New York - 1973 Annual Report.

discharge may be greater than the outflow possible from Lake Ontario.[1] This minimum is specified in the IJC's Orders of Approval which are implemented through the Plan of Operation 1958-D. In cases of high water levels in Lake

[1]When this condition exists the minimum discharge may be met for only a short period of time. The time is the amount required to draw down Lake St. Lawrence and is determined by the difference in releases at the control structure and the discharge from Lake Ontario divided into the storage of Lake St. Lawrence.

Table 13. EISENHOWER-SNELL LOCKS
Lockages and Transits 1973

	Lockages	Ships	Small Craft
March	28	33	0
April	434	466	2
May	733	801	27
June	740	791	100
July	845	802	614
August	809	745	411
September	671	692	106
October	702	759	25
November	693	777	3
December	382	426	1
TOTAL	6,037	6,292	1,289

Source: St. Lawrence Seaway Development Corporation, Massena, New York - 1973 Annual Report.

Ontario, such as the 1973-1974 period, large volume flows were released in order to reduce the levels of Lake Ontario. This effort resulted in what may be termed a "flow through" condition, i.e., the outflow from Lake Ontario equalled the discharge at the control structure but at a very high volume. This volume approached or was the maximum that could be discharged given the current capacity of the St. Lawrence River channel. As this condition was reached, Lake St. Lawrence became drawn down.

The results of these two cases are the same - shallow depths in the area of Lake St. Lawrence.

Thus, as stated earlier, navigational interests are not as interested in the level of Lake Ontario as they are in the relationship between the Lake's outflows and releases through the control structures, along with their respective magnitudes.

In addition to the gradient changes caused by varying the release rates, higher velocity currents are associated with increased release rates. These can become a hazard to navigation, since in many stretches of the River the navigation channel does not follow the river channel and currents arise that flow at various angles to the navigation channel. These currents tend to increase the difficulties of ship handling and thus reduce the safety of navigation.

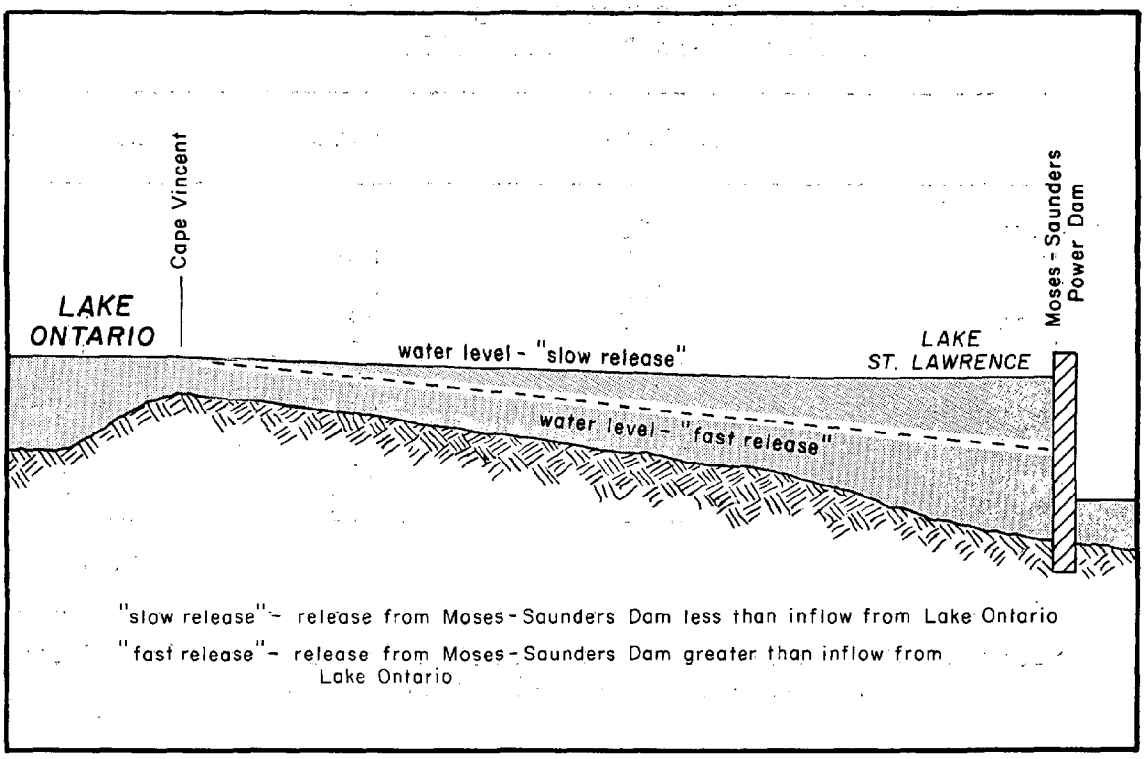


Figure 11. Relationship between release rates and navigational channel depths.

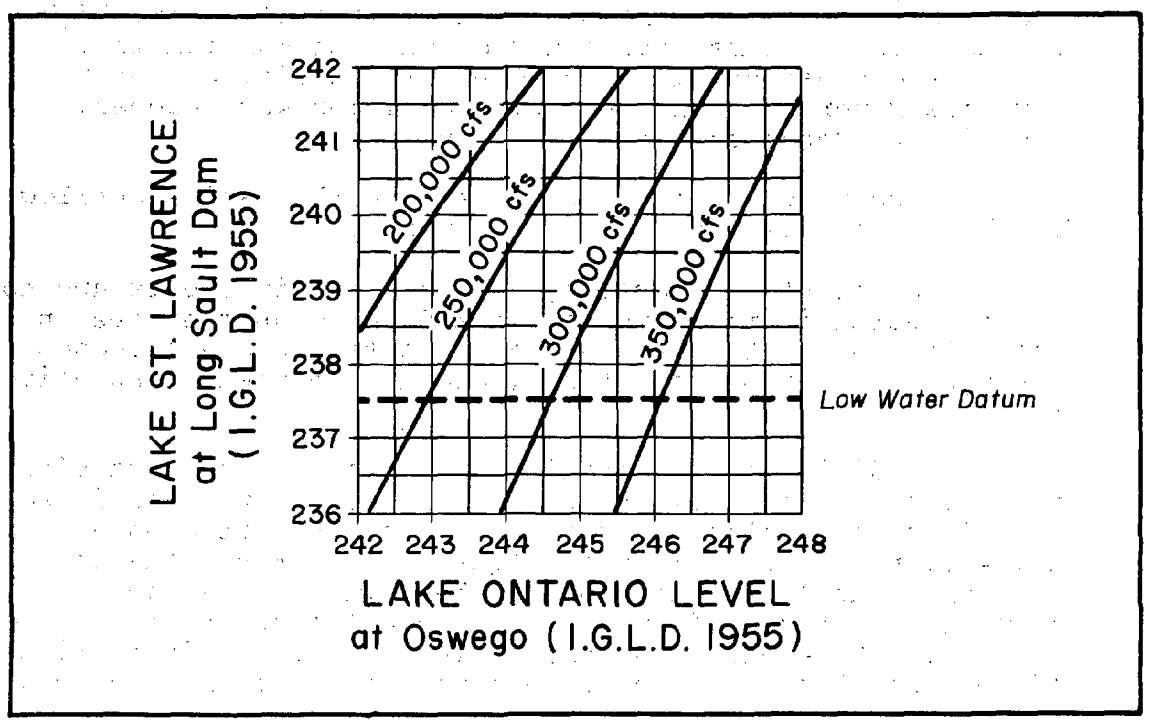


Figure 12. Effect of various Lake Ontario outflows on the level of Lake St. Lawrence (Source: Corps of Engineers, Buffalo District)

During periods of high water, in conjunction with high rates of discharge, damage is inflicted on shoreline property, in addition to accelerated erosion, by ships' wakes. To prevent or minimize this, the St. Lawrence Seaway Corporation has at various times issued speed restrictions on ships transiting the Seaway. Reduced speeds have increased transit time and therefore the cost per unit of shipping. Chapter IV discusses these costs in detail.

In summary, it seems fair to say that navigational interests desire to have maintained a lake level condition that will yield outflows to the St. Lawrence River that will minimize the problems associated with wake damage and channel depth while ensuring adequate water levels to maintain uninterrupted navigation.

2. Power Production

As the Seaway was being developed for navigation, the Power Authority of the State of New York (PASNY) and the Hydro Electric Power Commission of Ontario concurrently developed the hydro power potential of the International Rapids section of the St. Lawrence River. The major structure developed was the Robert Moses - Robert H. Saunders Power Dam near Massena, New York. This semi-outdoor type plant is 3,300 feet long. From lowest point of foundation to the top of the intake deck it rises 167 feet. It is 184 feet from upstream to downstream face. The dam was a joint venture with each power agency building half. Each half contains 16 generators with a rated capacity of 57,000 kilowatts each at 81 feet of head. Total rated capacity at this head for the dam is 1,824,000 kilowatts. Cost of the United States portion of the Power Dam with all electrical and other equipment was approximately $122,000,000.

Total cost of the power facilities connected with the development of the Seaway was approximately $650,000,000. The PASNY share of this total was about $350,000,000.

Other hydro electric power plants that preceeded the development of the Seaway are the Beauharnois and Cedars plants. Both are operated by Hydro Quebec, a power commission under Canadian jurisdiction.

Most of the discussion of lake water levels required to be compatible with power production requirements will center around the Moses-Saunders Dam since it is the largest of those on the St. Lawrence River. Thus, its requirements are the most encompassing.

The Moses-Saunders Power Dam is designed to pass flows up to 325,000 cfs. The power facility operates at maximum efficiency with a flow of about 270,000 cfs. This is for the production of its rated capacity under conditions when

normal head is available. This water use is non-consumptive in nature in that the water passes through the turbines with negligible loss to the St. Lawrence River. In general terms it can be said that any flow in excess of 270,000 cfs has lesser value to the production of electric power than flows under this amount. Flows in excess of 325,000 cfs have to be passed through the Long Sault Dam since they exceed the designed discharge capacity of the Moses-Saunders Dam and are therefore of zero value to power interests.

Table 14 reflects total production of the Moses Dam or United States portion by year. The years 1964 and 1965 were years of drought and low lake levels. This is reflected by lower total electric power production than during the recent years when lake levels have been high.

Table 14. Electric Power Production-Moses Power Dam[a]

YEAR	MWH
1958	1,298,075
1959	5,637,143
1960[b]	6,316,308
1961	6,260,641
1962	5,847,028
1963	5,834,029
1964	5,558,167
1965	5,402,602
1966	6,034,744
1967	6,384,455
1968	6,761,601
1969	6,982,254
1970	6,644,491
1971	6,774,906
1972	7,248,140
1973	7,704,369
1960-1973 Average	6,410,981

[a]Excludes data for the Canadian (Saunders) generating facility. See Table 17.

[b]First full year with full capacity as St. Lawrence project.

Source: Provided by Power Authority of the State of New York.

Table 15 provides data on power production from the Saunders Power Dam or Canadian portion. Although data on average production per year is not shown in the Table the actual production in 1973 and so far in 1974 was considered above average. This is accredited to the high water levels and subsequent high flows in the St. Lawrence River.[1]

Table 15. Electric Power Production - Saunders Power Dam

YEAR/MONTH		MWH
1973	January	765,000
	February	793,000
	March	896,000
	April	905,000
	May	906,000
	June	891,000
	July	868,000
	August	870,000
	September	852,000
	October	843,000
	November	837,000
	December	763,000
		10,189,000
1974	January	711,000
	February	765,000
	March	863,000
	April	884,000
	May	899,000
	June	886,000
	July	872,000
	August	856,000

Source: Provided by Hydro-Electric Power Commission of Ontario

[1]Correspondence dated September 22, 1974 from J. A. Keon, Assistant Plant Superintendent, St. Lawrence Power Development, Ontario Hydro.

Another factor that influences the releases desired by the electric companies, and therefore the level of Lake Ontario, is the fact that ice cover will not form in open water in the area of the St. Lawrence River if the velocity of flow exceeds approximately 2.5 feet per second with a flow of 220,000 cfs.[2] Thus, during construction of the Seaway and power facilities, the channels were widened and deepened and since completion, the flow has been regulated to maintain a maximum flow velocity of about 2.25 feet per second during the ice forming periods to ensure the formation of an ice cover. This cover is desirable to ensure that frazil ice does not form in open water and flow to areas covered with ice. If this formation and flow did occur, the frazil ice would be drawn under the existing ice cover and would tend to freeze, forming in effect, an ice dam. This in turn would reduce the flow and be detrimental to the production of power when and if the reduced flow became less than 270,000 cfs. In addition, upstream flooding could be caused.

In summary, power interests desire to maintain a flow of approximately 270,000 to 325,000 cfs throughout that portion of the year when an ice cover is not present. During the ice forming period, they would prefer to maximize the flow within the constraint of not exceeding a flow velocity of 2.25 feet per second at 220,000 cfs. (This is based on the assumption that the minimum flow to meet this constraint is less than 270,000 cfs.)

After a solid ice cover has formed, they would prefer to increase the releases to the maximum consistent with maintaining the ice cover and not exceeding 270,000 to 325,000 cfs. The rationale behind this last statement lies in the fact that the winter months are the peak demand months for electricity produced by the PASNY system which Moses-Saunders Dam is a component of.[3] Therefore, for most efficient production a flow of 270,000 cfs is desired.

B. Land

The following discussion of land is limited to the properties which border directly on Lake Ontario or the St.

---

[2]Experience has shown that a satisfactory ice cover can be formed with flows in the order of 235,000 cfs.

[3]Peak demand for power produced by PASNY was in the month of December in both 1972 and 1973. (1974 Report of Member Electric Corporation of the New York Power Pool and the Empire State Electric Energy Research Corporation) PASNY personnel state that "the Authority's firm contracts for firm power require that the Authority deliver fixed quantities of energy throughout the year."

Lawrence River. This area will be described relative to its current use, hazardous zones and environmental value.[4]

1. Use

Three categories of shoreland use have been defined. They are recreation which includes all designated outdoor recreation lands; commercial, residential, industrial and public buildings; and agricultural lands and open space.

Table 16 reflects the percentage of each of these categories for each county within the United States for the entire United States shoreline of Lake Ontario and the St. Lawrence River, for the Canadian shoreline of Lake Ontario from the Niagara River to Cornwall and from Cornwall to Montreal. As can be seen, the percentage in the agricultural and open space category is slightly higher for the Canadian portion than for the United States portion of their respective shorelines. Figures 13 through 18 depict the geographic distribution of the shoreland use.

2. Hazardous Zones

The shoreline of Lake Ontario and the St. Lawrence River was examined and categorized as either erodable with protection, erodable without protection or subject to flooding. The areas not shown as falling within one of these categories on Figures 13 through 18 were considered not erodable or not subject to flooding.

Protection of erodable areas refers to protective devices provided by a public entity such as the Corps of Engineers or Department of Environmental Conservation in the United States and federal or provincial agencies in Canada. Also included are substantial protective structures provided in urban areas. Small scale private protection of individual properties was not considered adequate to provide long term protection from flooding or to prevent erosion.

Table 17 shows the entire United States portion and the Lake Ontario to Cornwall on the St. Lawrence River portion of the Canadian shoreline that falls within each of the above categories. Approximately 50 percent of the United States shoreline is classified as erodable. Of this a small portion, 11.2% is protected. Table 18 reflects the portion of the Canadian shoreline from Cornwall to Montreal that is erodable.

---

[4]The Corps of Engineers has gathered and analyzed detailed data on land use, hazardous zones and environmental values. However, due to budgetary limitations, this data has not been published in detailed form to date.

Table 16 - Shoreland Use - Lake Ontario and St. Lawrence River

Area	Recreation		Residential[a]		Ag. & Open Space	
	Miles	% of Area	Miles	% of Area	Miles	% of Area
United States						
Niagara County	5.9	19%	16.5	53%	8.7	28%
Orleans County	2.2	9%	17.8	74%	4.0	17%
Monroe County	31.0	88%	1.3	4%	2.7	8%
Wayne County	7.4	17.3%	28.2	65.4%	7.4	17.3%
Cayuga County	.8	10.3%	3.3	41.4%	3.9	48.3%
Oswego County	3.1	9.2%	20.3	59.6%	10.6	31.2%
Jefferson County	3.6	3%	62.4	52%	54.0	45%
St. Lawrence County	7.6	10%	31.2	41%	37.2	49%
United States	61.8	16.6%	181.5	48.8%	128.7	34.6%
Canada						
Niagara River to Cornwall	160.0	13.6%	476.0	40.4%	542.0	46.0%
Cornwall to Montreal	99.2	28.2%	109.1	31.0%	144.4	40.8%
Canada	259.2	17.0%	585.1	38.2%	686.4	44.8%

[a]Residential includes residential, commercial, industrial and public building.

Source: United States data adapted from National Shoreline Study, Department of the Army, August, 1971.

Canadian data - Shore Erosion On the Great Lakes - St. Lawrence System, Part 1-3, Government of Canada, 1973.

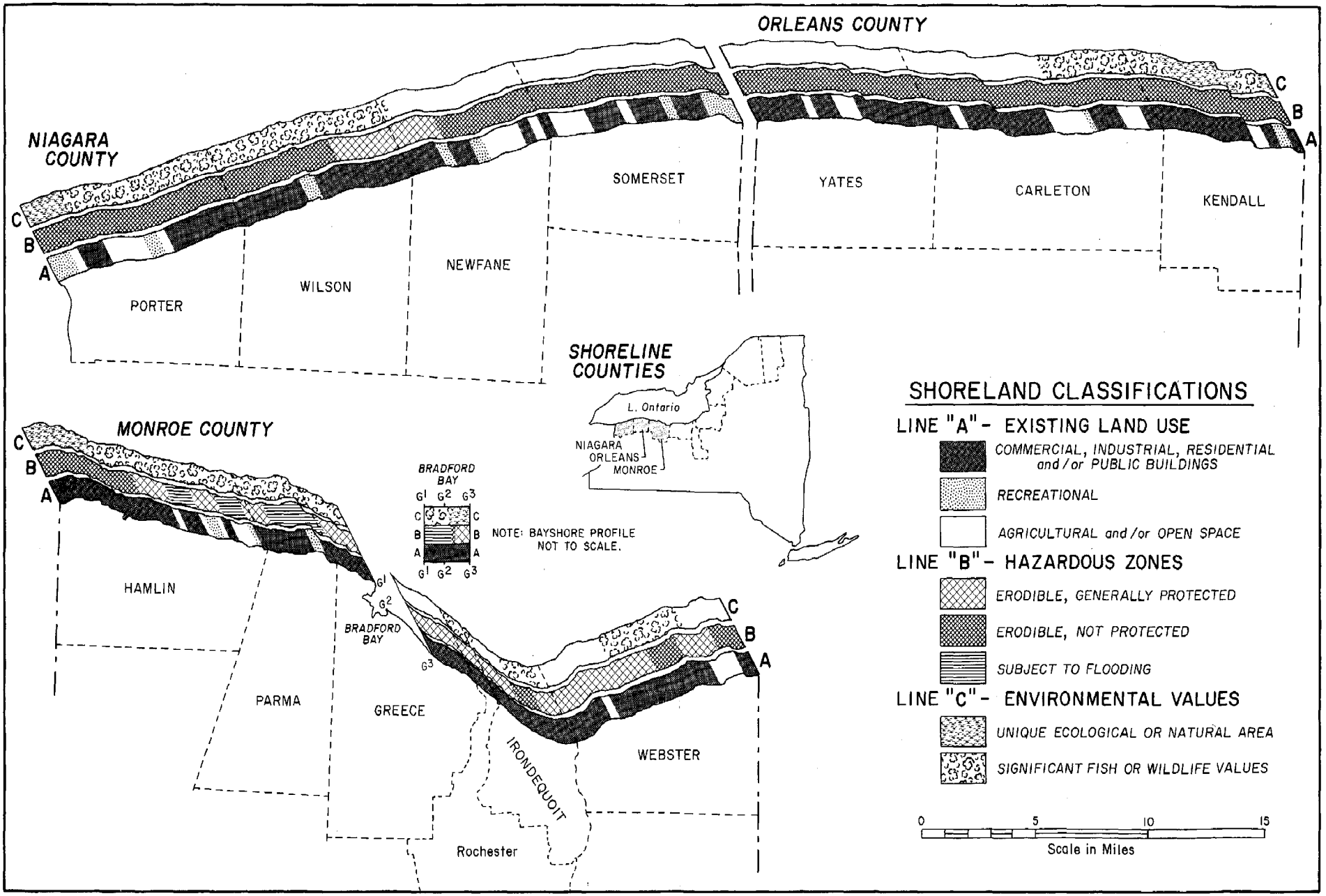


Figure 13. Shoreland Uses, Hazardous Areas and Environmental Values: Niagara, Orleans and Monroe Counties. (Source: Great Lakes Region Inventory Report, National Shoreline Study, Corps of Engineers, 1971)

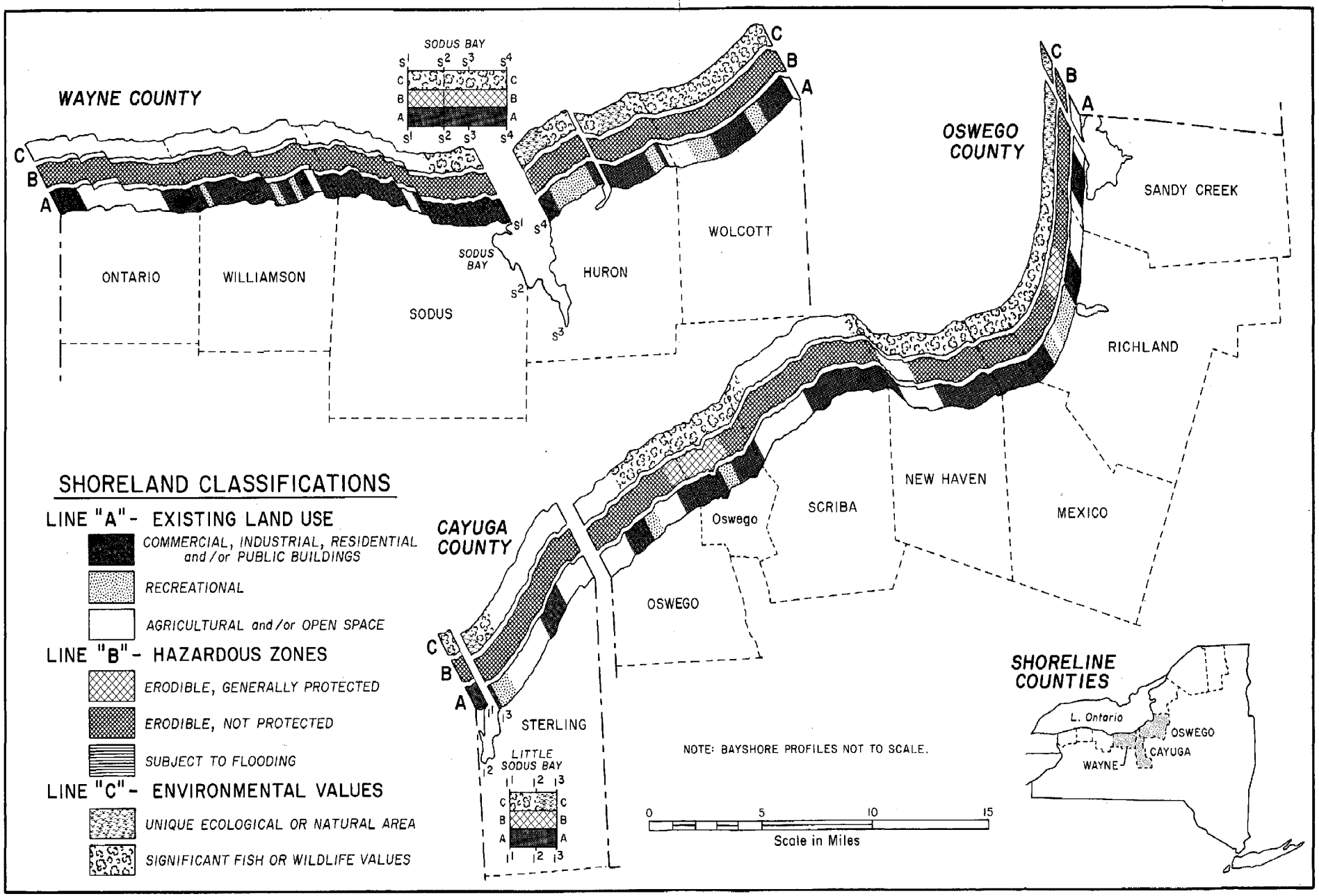


Figure 14. Shoreland Uses, Hazardous Areas and Environmental Values: Wayne, Cayuga and Oswego Counties. (Source: Great Lakes Region Inventory Report, National Shoreline Study, Corps of Engineers, 1971)

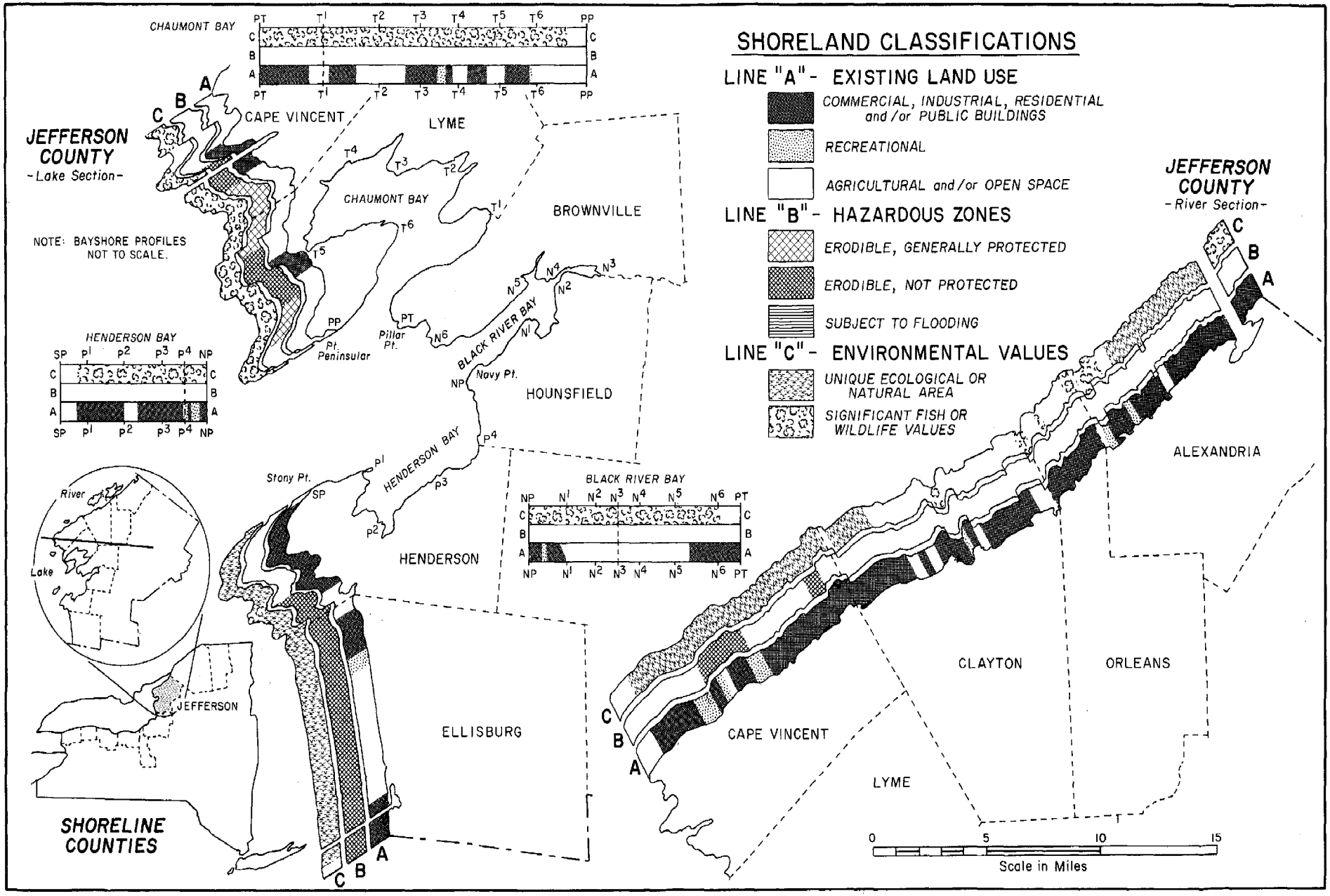


Figure 15. Shoreland Uses, Hazardous Areas and Environmental Values: Jefferson County (Source: Great Lakes Regional Inventory Report, National Shoreline Study, Corps of Engineers, 1971)

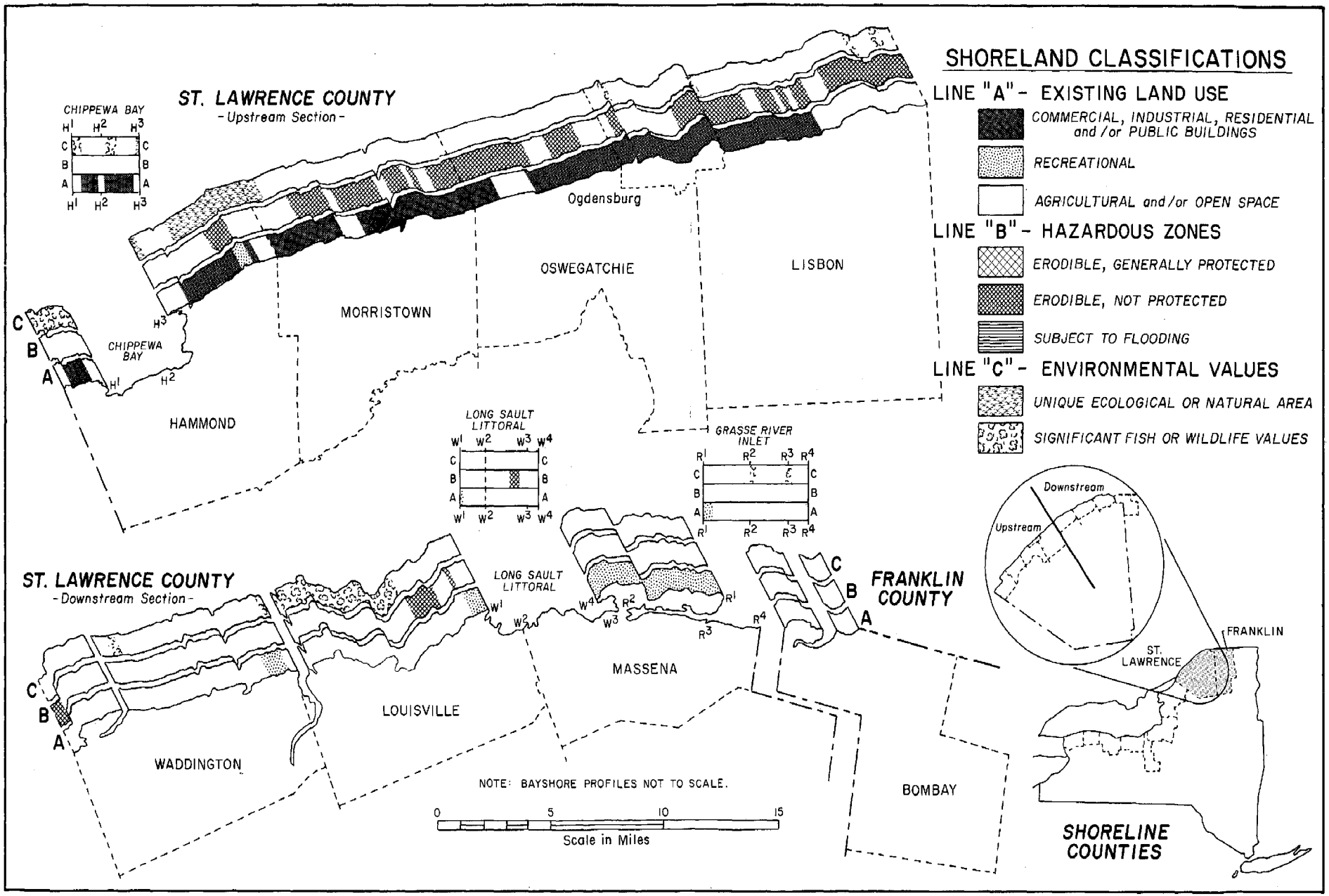


Figure 16. Shoreland Uses, Hazardous Areas and Environmental Values: St. Lawrence and Franklin Counties (Sources: St. Lawrence-Eastern Ontario Shoreline Study, 1972, Soil Conservation Service Personnel Interpretation and Land Use and Natural Resource Inventory Quadrangle Maps, 1968)

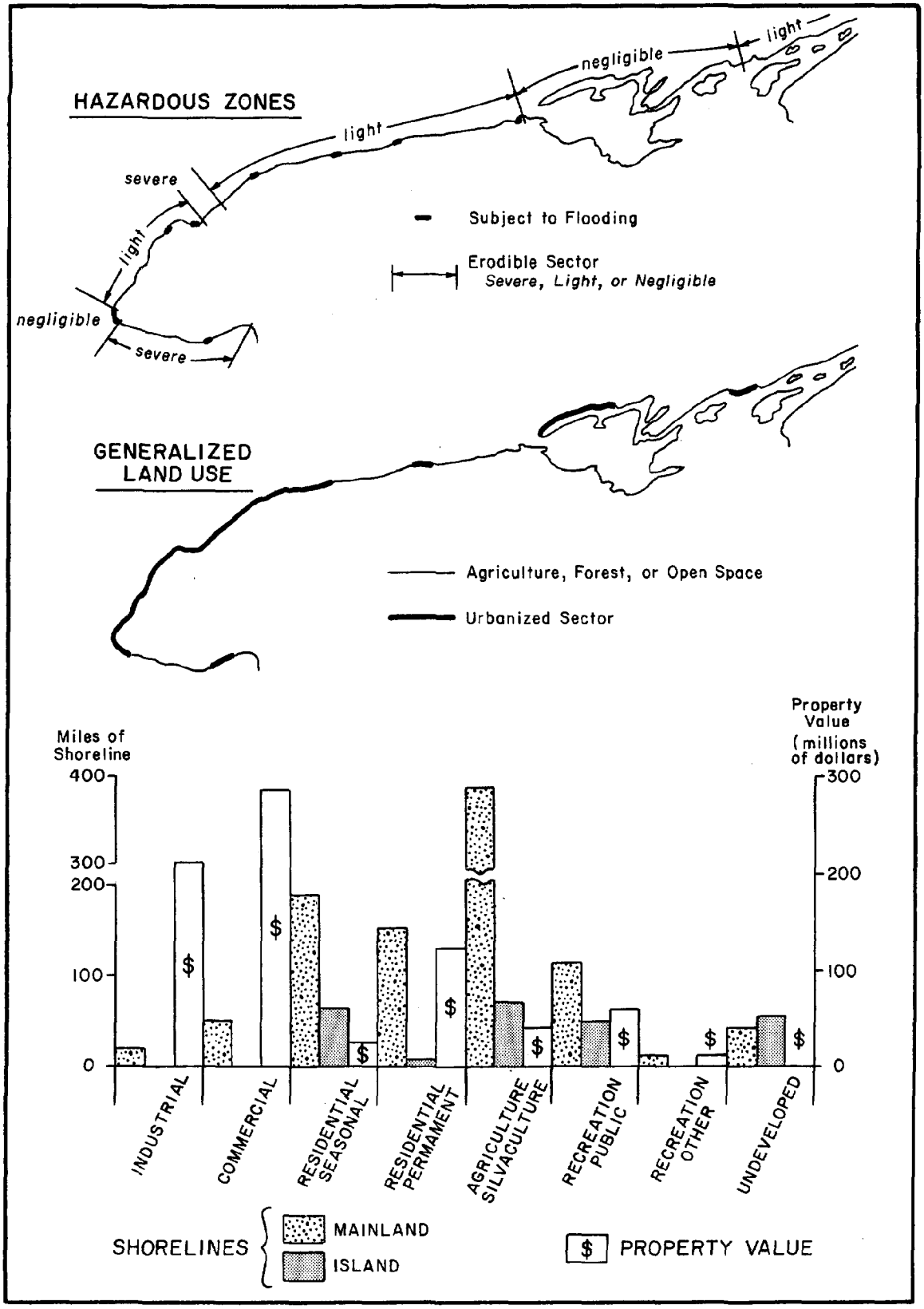


Figure 17. Hazardous Zones and Land Use - Canadian Section of Lake Ontario (Source: Shore Erosion on the Great Lakes-St. Lawrence System, Government of Canada, 1973)

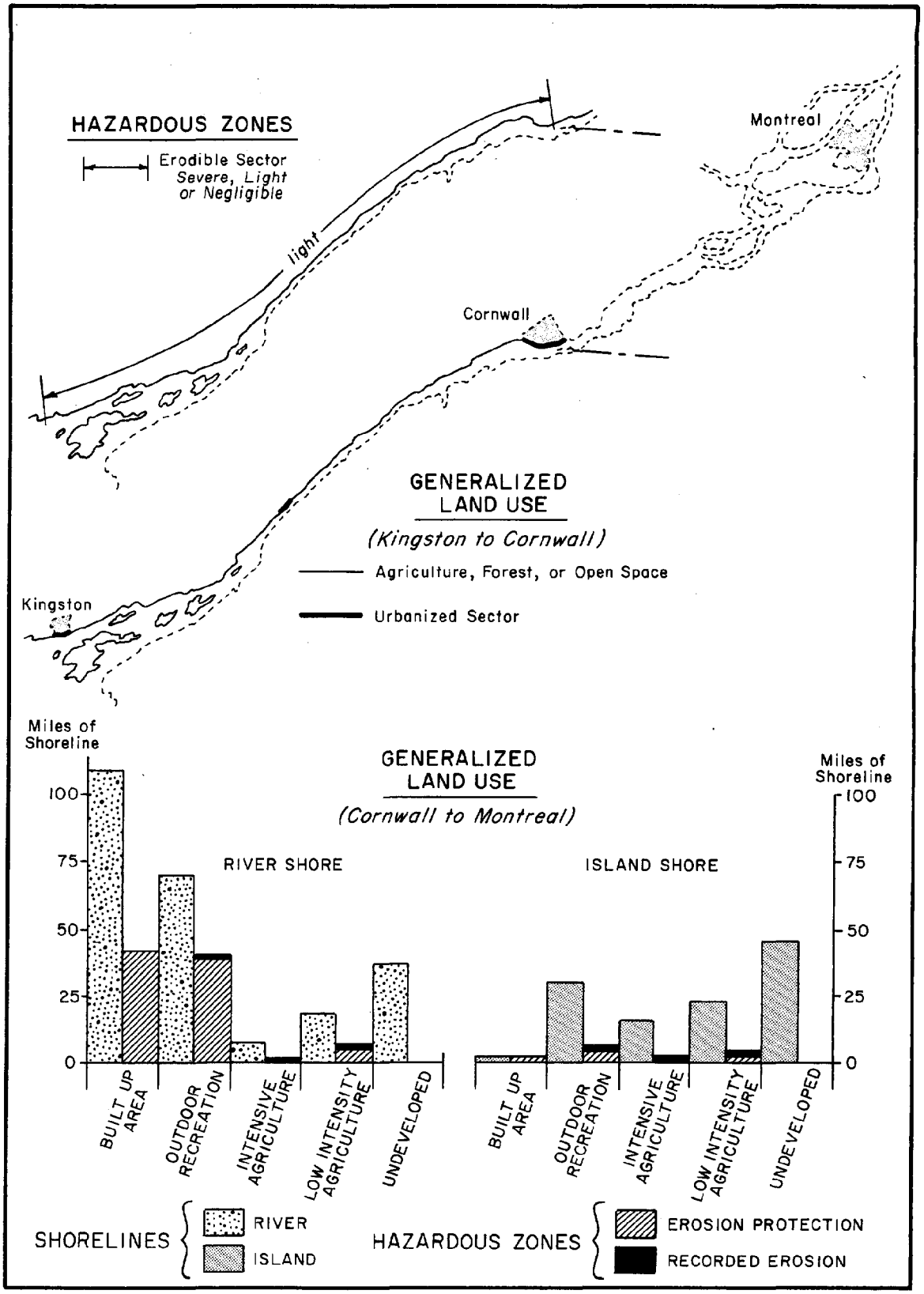


Figure 18. Hazardous Zones and Shoreland Uses - Canadian Section of the St. Lawrence River (Source: Shore Erosion on the Great Lakes-St. Lawrence System, Government of Canada, 1973)

Table 17. Hazardous Zones - Lake Ontario and St. Lawrence River

Area	Erodible (Protected)		Erodible (Not Protected)		Subject to Flooding	
	Miles	% of Area	Miles	% of Area	Miles	% of Area
Niagara	1.6	5.2%	8.1	26%	0	0%
Orleans	0	0%	24.0	100%	0	0%
Monroe	20.5	58.6%	7.4	21%	7.1	20.4%
Wayne	1.2	3%	41.8	97%	0	0%
Cayuga	.6	7%	7.4	93%	0	0%
Oswego	4.4	13%	21.9	64.5%	0	0%
Jefferson	13.2	11%	12	10%	0	0%
St. Lawrence	0	0%	24	31.6%	0	0%
United States	41.5	11.2%	146.6	39.4%	7.1	2%
Canada:						
Lake Ontario to Cornwall	120	10%	1058	90%	0	0%

Source: United States data adopted from National Shoreline Study, Department of the Army, August, 1971.

Canadian data - Shore Erosion on the Great Lakes - St. Lawrence System, Part 1-3, Government of Canada, 1973.

Table 18 - Hazardous Zones - Cornwall to Montreal

Land Use	Protection Works		Recorded Erosion	
	Miles	% of Area	Miles	% of Area
Residential	42.6	46.4%	0	0%
Recreation	42.1	45.8%	1.0	16.4%
Agriculture	7.1	7.8%	5.3	83.6%
Total	91.8	100%	6.3	100%

Source: Shore Erosion On the Great Lakes - St. Lawrence System, Part III, Government of Canada, 1973.

It should be noted that the definition of the word "erodible" changes for the three areas - United States portion, Lake Ontario to Cornwall and Cornwall to Montreal - and thus they are not comparable. An example of this is that the entire Lake Ontario to Cornwall shoreline in Canada is classified as erodable while only about 2% of the Cornwall to Montreal section is so classified.

As the included series of Tables and Figures show, only a small portion of the shoreline is subject to flooding in the United States. Canadian sources did not provide data relative to the flooding hazard on the Canadian shoreline.

3. Environmental Values

Two categories of environmental values were established: unique ecological or natural areas and significant fish and wildlife areas. Comparable data for the Canadian shoreline were not available.

Such areas provide desired amenities in terms of recreation and aesthetics, and are important to the economy of the region since a large portion of its employment is based on the provision of services to tourists and visiting recreationists. As can be seen in Figures 13 through 16, about 50 percent of the United States shoreline falls within one of these two classifications.

The composite Figures 13-16 depicting shoreland use, hazardous zones and environmental values allow one to evaluate shoreland use in relation to environmental values. Although these Figures are general, they provide an overview of man's interaction with nature in the shoreland area. More detailed data would be useful in planning for greater compatability between developmental activities and natural environmental conditions.

CHAPTER IV

IMPACT OF WATER LEVELS DURING THE CURRENT PERIOD OF HIGH WATER (JANUARY, 1973 THROUGH AUGUST, 1974)

A. Interest Groups Affected

During the period of January, 1973 through August, 1974, all interest groups utilizing the waters and adjacent land of Lake Ontario and the St. Lawrence River have been impacted by the high water. Both positive and negative impacts have been sustained. The incidences and magnitudes of these impacts are difficult to identify and quantify.

However, a general understanding of the nature of the impact on the various interest groups can be derived through examination and interpretation of data related to each group. Such efforts were undertaken and the results are described below.

Table 19 summarizes Lake Ontario water level data and the influence of these levels on each sector - power, navigation and riparian owners. The data in this table will aid in understanding the impacts described in the following sections.

1. Power Production

The impact of the high water on the power producers can be estimated by examining river flows and power output and revenues of the hydro power plants operating on the St. Lawrence River.

As described earlier there are four hydro plants operating on the St. Lawrence River. The largest is the Moses-Saunders Power Facility operated jointly by Canadian and United States interest. The impact of water levels on the production at the Moses Power Facility can be seen in Table 20 by relating output (KWH) to the average level of the Lake for the year in question.

As is reflected in Table 20, 1962 through 1965 were years of less than average production. Lake Ontario was classified as having low water levels throughout this entire period. In the years 1972 and 1973, production well in excess of the average was achieved by the Moses

Table 19. Summary of Lake Ontario Water Data and Impacts

Date	Daily Mean Elevation	Daily Outflow (cfs)	Average Daily Inflow For Week (cfs)	Lake Level[a]	Power[b]	Navigation[c]	Upstream Riparian[d]
1973							
1-3	245.45	260,000	352,000	R		C	
1-10	245.59	230,050	285,000	R		C	
1-17	245.70	255,070	278,000	R		C	
1-24	245.87	250,040	319,000	R		C	
1-31	246.01	232,730	302,000	R		C	
2-7	246.31	269,920	350,000	C		C	
2-14	246.31	290,790	284,000	F	X	C	
2-21	246.25	290,150	268,000	F	X	C	
2-28	246.15	294,850	256,000	R	X	C	
3-7	246.24	299,800	329,000	R	X	C	
3-14	246.47	290,120	381,000	R	X	C	
3-21	246.95	297,050	463,000	R	X	C	X
3-28	247.06	310,000	348,000	R	X	R	X
4-4	247.43	316,000	453,000	R	X	R	X
4-11	247.82	319,000	430,000	F	X	R	X
4-18	247.77	330,000	319,000	R	X	R	X
4-25	247.81	331,000	344,000	R	X	R	X

a - R - indicates rising lake level; F - indicates falling lake level; C - indicates constant lake level
b - X - indicates full power production
c - R - indicates speed restrictions in effect; C - indicates Seaway is closed
d - X - indicates elevation of Lake Ontario exceed 246.77

Table 19. Summary of Lake Ontario Water Data and Impacts (continued)

Date	Daily Mean Elevation	Daily Outflow (cfs)	Average Daily Inflow For Week (cfs)	Lake Level[a]	Power[b]	Navigation[c]	Upstream Riparian[d]
1973							
5-2	247.90	332,000	368,000	R	X	R	X
5-9	247.94	333,000	343,000	R	X	R	X
5-16	247.97	334,000	344,000	F	X	R	X
5-23	247.96	340,000	336,000	R	X	R	X
5-30	247.99	345,000	351,000	F	X	R	X
6-6	247.96	350,000	341,000	F	X	R	X
6-13	247.91	350,000	329,000	F	X	R	X
6-20	247.79	350,000	304,000	F	X	R	X
6-27	247.68	350,000	319,000	F	X	R	X
7-4	247.61	350,000	322,000	F	X	R	X
7-11	247.45	351,000	286,000	F	X	R	X
7-18	247.21	350,000	273,000	F	X	R	X
7-25	246.97	350,000	261,000	F	X	R	X
8-1	246.85	350,000	310,000	F	X	R	X
8-8	246.64	335,000	266,000	F	X	R	
8-15	246.45	320,000	258,000	F	X	R	
8-22	246.29	317,000	255,000	F	X		
8-29	246.12	310,000	261,000	F	X		

a - R - indicates rising lake level; F - indicates falling lake level; C - indicates constant lake level
b - X - indicates full power production
c - R - indicates speed restrictions in effect; C - indicates Seaway is closed
d - X - indicates elevation of Lake Ontario exceed 246.77

Table 19. Summary of Lake Ontario Water Data and Impacts (continued)

Data	Daily Mean Elevation	Daily Outflow (cfs)	Average Daily Inflow For Week (cfs)	Lake Level[a]	Power[b]	Navigation[c]	Upstream Riparian[d]
1973							
9-5	245.97	318,000	263,000	F	X		
9-12	245.69	320,000	210,000	F	X		
9-19	245.46	320,000	238,000	F	X		
9-26	245.32	315,000	271,000	F	X		
10-3	245.15	310,000	252,000	F	X		
10-10	245.01	310,000	259,000	F	X		
10-17	244.83	310,000	249,000	F	X		
10-24	244.64	305,000	242,000	F	X		
10-31	244.60	290,000	280,000	F	X		
11-7	244.47	300,000	255,000	F	X		
11-14	244.28	295,000	237,000	F	X		
11-21	244.30	285,000	293,000	F	X	C	
11-28	244.30	288,000	292,000	C	X	C	
12-5	244.28	288,000	280,000	F	X	C	
12-12	244.30	287,000	294,000	R	X	C	
12-19	244.23	258,000	256,000	F		C	
12-26	244.43	230,000	323,000	R		C	

a - R - indicates rising lake level; F - indicates falling lake level; C - indicates constant lake level
b - X - indicates full power production
c - R - indicates speed restrictions in effect; C - indicates Seaway is closed
d - X - indicates elevation of Lake Ontario exceed 246.77

Table 19. Summary of Lake Ontario Water Data and Impacts (continued)

Date	Daily Mean Elevation	Daily Outflow (cfs)	Average Daily Inflow For Week (cfs)	Lake Level[a]	Power[b]	Navigation[c]	Upstream Riparian[d]
1974							
1-2	244.74	230,000	333,000	R		C	
1-9	244.88	238,000	282,000	R		C	
1-16	245.04	242,000	255,000	R		C	
1-23	245.11	255,000	289,000	R		C	
1-30	245.37	252,000	355,000	R		C	
2-6	245.55	240,000	293,000	R		C	
2-13	245.61	270,000	275,000	C	X	C	
2-20	245.61	280,000	273,000	R	X	C	
2-27	245.69	290,000	306,000	R	X	C	
3-6	245.84	300,000	366,000	R	X	C	
3-13	245.90	293,000	313,000	R	X	C	
3-20	245.95	300,000	314,000	F	X	C	
3-27	245.92	310,000	296,000	R	X	R	
4-3	246.08	310,000	368,000	R	X	R	
4-10	246.35	308,0000	411,000	R	X	R	
4-17	246.57	310,000	384,000	R	X	R	
4-24	246.75	310,000	375,000	R	X	R	

a - R - indicates rising lake level; F - indicates falling lake level; C - indicates constant lake level
b - X - indicates full power production
c - R - indicates speed restrictions in effect; C - indicates Seaway is closed
d - X - indicates elevation of Lake Ontario exceed 246.77

Table 19. Summary of Lake Ontario Water Data and Impacts (continued)

Date	Daily Mean Elevation	Daily Outflow (cfs)	Average Daily Inflow For Week (cfs)	Lake Level[a]	Power[b]	Navigation[c]	Upstream Riparian[d]
1974							
5-1	246.85	310,000	339,000	R	X	R	X
5-8	246.88	310,000	324,000	R	X	R	X
5-15	247.17	310,000	416,000	R	X	R	X
5-22	247.41	300,000	386,000	R	X	R	X
5-29	247.53	310,000	341,000	C	X	R	X
6-5	247.53	320,000	315,000	F	X	R	X
6-12	247.47	330,000	305,000	R	X	R	X
6-19	247.48	330,000	336,000	F	X	R	X
6-26	247.42	330,000	300,000	R	X	R	X
7-3	247.46	330,000	346,000	F	X	R	X
7-10	247.41	333,000	314,000	F	X	R	X
7-17	247.20	337,000	262,000	F	X	R	X
7-24	246.97	340,000	255,000	F	X	R	X
7-31	246.84	340,000	298,000	F	X	R	X
8-7	246.81	340,000	283,000	F	X		X
8-14	246.45	335,000	255,000	F	X		
8-21	246.25	324,000	258,000	F	X		
8-28	246.05	320,000	248,000		X		

a - R - indicates rising lake level; F - indicates falling lake level; C - indicates constant lake level
b - X - indicates full power production
c - R - indicates speed restrictions in effect; C - indicates Seaway is closed
d - X - indicates elevation of Lake Ontario exceed 246.77

Source: Adapted from Lake Ontario Data, Dept. of the Army, Corps of Engineers, (Weekly).

Table 20. Relationship Between Time, Production and Lake Ontario Levels - Moses Power Dam

Year	Production (KWH)	Production Index [a]	Lake Level[b]
1960	6,316,308	99	Average
1961	6,260,641	98	Average
1962	5,847,028	91	Low
1963	5,834,029	91	Low
1964	5,558,167	87	Low
1965	5,402,602	84	Low
1966	6,034,744	94	Low
1967	6,384,455	99	High
1968	6,761,601	105	Average
1969	6,982,254	109	High
1970	6,644,491	104	Average
1971	6,774,906	106	Average
1972	7,248,140	113	High
1973	7,704,369	120	High
1960-1973 Average	6,410,981	100	

[a]The index is the ratio of production of a given year to the average production for the 14 year period during which the facility has operated at full production times 100.

[b]The lake level was classified by comparing a graph of average levels for the period of record with a graph of the recorded water levels for each year between 1960 and 1973. From this a determination was made whether the lake level was in general high, low or average.

Power Dam. These two years were classified as years of high water levels on Lake Ontario.

Examination of the recorded flow at the Ogdensburg gauge provides data upon which to determine the percent of time that the flow of the St. Lawrence River was above the 270,000 cfs required for most efficient production of the Moses-Saunders Power Dam. Over the past 24 years (1950-1973) the flow of the St. Lawrence River at this point has exceeded 270,000 cfs 28 percent of the time. This compares to 87 percent in 1973 and 74 percent in 1974.[1] In contrast, at no time in the 1962 through 1966 period did the mean daily flow exceed 270,000 cfs.

The fact that power production has been well above average during the last two years, in conjunction with no reports of physical damage to or operational difficulties of the power producing facilities, leads one to conclude that the impact on power interests - producers and consumers has been positive and significant in magnitude. This latter statement is based on the following revenue data. Revenue from the sale of St. Lawrence Power averaged $29.3 million for 1970 and 1971. Average production for those two years was 5 percent above the long term average. Revenue for 1973 amounted to $32.2 million.[2] Thus, about a 14 percent increase above the long term average was achieved in 1973.

In addition there were considerable savings passed on to the ultimate consumer of the electricity produced by PASNY. Legislation authorizing PASNY requires the private utility companies to pass on to their customers any savings in production cost associated with purchasing power from PASNY rather than generating it themselves. In fact, over 19 million dollars of such savings have been passed on by the private utilities during the 1959-1973 period. During 1973 alone, the savings totalled $4,970,000. This amounted to about 26% of the 15 year total.[3]

---

[1] For the period January through August, 1974.

[2] Data provided by Power Authority of the State of New York.

[3] This large percentage is due to two factors: the primary one being the large amount of power produced in 1973 compared to the average production, and secondarily the fact that the unit price of electricity has increased approximately 26 percent in the 15 year period ending in 1973.

2. Navigation

The high water levels experienced in the last two years have impacted upon navigation on the St. Lawrence Seaway. This impact has been reflected through vessel speed restrictions imposed throughout parts of the past two navigational seasons and in increased hazards encountered in navigation. Both of these impacts will be discussed.

Due to the potential of inflicting damage on shore property and natural resources by wave action caused by ships' wakes, vessel speed restrictions were imposed over various portions of the St. Lawrence Seaway. Figure 19 depicts the division of the Seaway into navigational zones while Table 21 reflects the normal and restricted speeds for these various zones. Table 22 relates the times during which speeds were restricted and the zones within which these restrictions were imposed.

The economic impact of these speed restrictions was approximated in the following manner. Increased transit times due to the reduced speeds were determined. Ships transiting the Seaway during the times that restrictions were imposed were classified as indicated in Table 23 along with the operating costs per hour for each class.

Operating costs were multiplied by the increased hours of transit required due to the reduced speeds. This provided an estimate of the direct cost to navigation resulting from reduced Seaway speeds. Estimates of indirect costs such as reduced number of trips over the navigational season were not derived since it was felt that the increased travel time resulting from the speed restrictions was not significant when compared to the overall normal total trip time of a vessel. Direct increased costs derived by the above method amounted to $1,953,075 based on 32,386 hours of increased transit time required.[4]

A breakdown of the increased operating costs by year and class of ship is shown in Table 24. Also reflected is the percentage that this increase in cost was of total operating costs of transiting the Montreal to Lake Ontario section of the Seaway. As indicated, this increase is approximately 12 percent of the normal operating cost. This is a significant increase. However, the increase as

---

[4]The St. Lawrence Seaway Development Corporation estimates that the 2,025 commercial vessels transiting the Seaway in 1973 incurred an increase in cost of 1.8 million dollars.

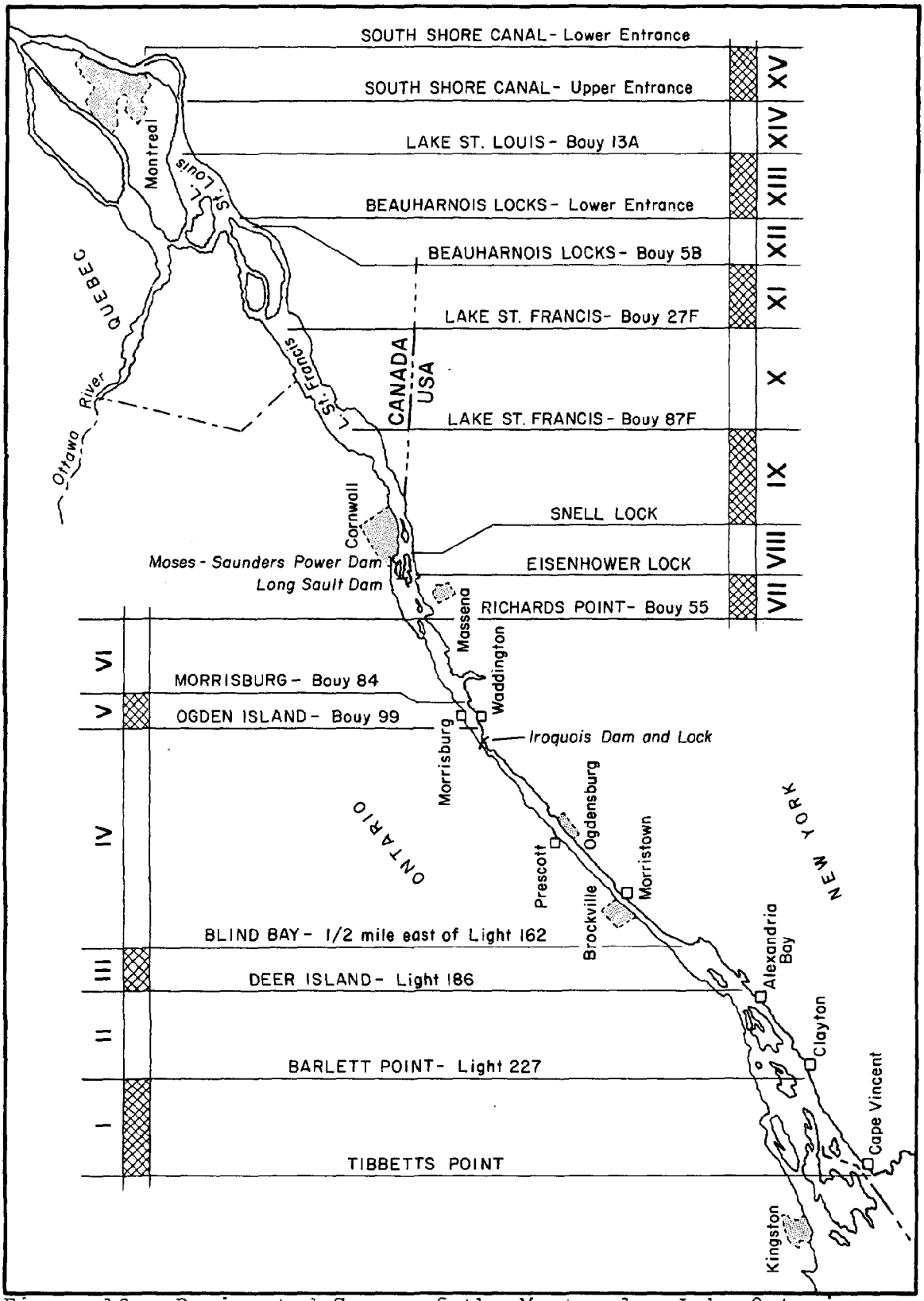


Figure 19. Designated Zones of the Montreal - Lake Ontario Section of the St. Lawrence Seaway. (Source: St. Lawrence Seaway Development Corporation)

Table 21. Table of Normal and Restricted Speeds.

Zone	From	To	Statute Miles	Maximum Speed Over the Bottom (MILES PER HOUR) Normal Speed	Restricted Speed
I	Bartlett Point Lt. 227	Tibbets Point	17.8	15 (13 knots)	12 (10.4 knots)
II	Deer Island Lt. 186	Bartlett Point Lot. 227	13.2	10 upbd (8.6 knots) 12 dnbd (10.4 knots)	9 upbd (7.8 knots) 12 dnbd (10.4 knots)
III	Blind Bay 1/2 mi. east of Lt. 162	Deer Island Lot. 186	10.1	13 (11.3 knots)	12 (10.4 knots)
IV	Ogden Island Buoy 99	Blind Bay 1/2 mi. east of Lt. 162	38.3	15 (13 knots)	12 (10.4 knots)
V	Morrisburg Buoy 84	Ogden Island Buoy 99	4.9	13 (11.3 knots)	12 (10.4 knots)
VI	Richards Point Lt. 55	Morrisburg Buoy 84	10.3	15 (13 knots)	12 (10.4 knots)
VII	Eisenhower Lock	Richards Point	5.7	13 (11.3 knots)	12 (10.4 knots)
IX	Lake St. Francis Buoy 87F	Snell Lock	16.0	10 upbd (8.6 knots) 12 dnbd (10.4 knots)	9 upbd (7.8 knots) 12 dnbd (10.4 knots)

Table 21. Table of Normal and Restricted Speeds. (continued)

Zone	From	To	Miles	Maximum Speed Over the Bottom (MILES PER HOUR) Normal Speed	Restricted Speed
X	Lake St. Francis Buoy 27F	Lake St. Francis Buoy 87F	17.4	18 (15.5 knots)	18 (15.5 knots)
XI	Upper Entrance Beauharnois Lock Buoy 5B	Lake St. Francis Buoy 27F	15.1	10 upbd[a] (8.6 knots) 12 dnbd (10.4 knots)	10 upbd (8.6 knots) 12 dnbd (10.4 knots)
XIV	Lake St. Louis Buoy 13A	Lower Entrance Beauharnois Lock	8.6	18 (15.5 knots)	18 (15.5 knots)
XV	Upper Entrance South Shore Canal	Lake St. Louis Buoy 13A	1.9	12 (10.4 knots)	12 (10.4 knots)
	Junction of Canadian Middle Channel & Main Channel abreast of Ironsides Is.	Open Waters between Wolfe & Howe Island through the said Middle Channel	21.2	13 (11.3 knots)	11 (9.5 knots)
	All other canals			7 (6.1 knots)	7 (6.1 knots)

[a] upbd means upbound; dnbd means downbound

Source: St. Lawrence Seaway Development Corporation, Massena, New York

Table 22. Period of Speed Restriction - St. Lawrence Seaway

Zone	1973	1974
I	March 27 - August 15	May 28 - July 28
II	April 10 - August 15	May 28 - July 28
III	April 10 - August 15	May 28 - July 28
IV	March 27 - August 15	May 28 - July 28
V	April 10 - August 15	May 28 - July 28
VI	April 10 - August 15	May 28 - July 28
VII	April 10 - August 15	May 28 - July 28
VIII	a	a
IX	April 10 - August 15	May 28 - July 28
X	a	a
XI	a	a
XII	a	a
XIII	a	a
XIV	a	a
XV	a	a

a - No restrictions imposed.

Source: Seaway Notice Affecting Navigation, St. Lawrence Seaway Development Corporation, 1973-1974.

a percent of total trip costs would normally be much less. No estimate was made of this due to the diverse nature of origins and destinations of the ships transiting the Seaway.

Other costs incurred are damages to ships and/or navigation facilities due to grounding or collision.

Table 23. Number of Ships By Class Transiting St. Lawrence Seaway During Restricted Periods and Operating Costs Per Hour

Class	Length (ft)	1973	1974	Cost/Hour ($)
A	Under 400	1334	408	160[a]
B	400-499	535	153	221
C	500-599	332	104	252
D	600-649	349	137	297
E	650-699	342	143	328
F	700-730	120	63	348
G	731-849	462	239	366
TOTALS		3474	1247	

[a]Extrapolated from a graph reflecting the cost per hour and the length of vessel for classes B through G.

Sources: Eisenhower Lock Transit Log, St. Lawrence Seaway Development Corporation.

Regulation of Great Lakes Water Levels, Appendix E, International Great Lakes Levels Board, 1973.

Estimates of these costs were provided by the St. Lawrence Seaway Development Corporation. They total about $100,000 with $76,000 in damages to vessels and facilities and $30,000 resulting from about 100 hours of lost time. The incidents through which these costs were incurred are listed in Table 25.

Additional costs are also incurred when the Seaway is operated at minimum profile, as it did in the Fall of 1972, 1973 and 1974. Under this condition it is very sensitive to meteorological effects and any shift in the wind to a north, northeast or east direction can drop the water levels below the minimum profile. For example, on the first three days of December 1974 a total of 27 commercial vessels were affected over a period of about 46 hours.

Table 24. Operating Costs - Normal and Restricted Speeds

Class	Normal Speed	1973 Restricted Speed	Cost Increase	Percent Cost Increase
A	$ 2,882,804.80	$ 3,241,083.20	$ 358,278.40	12.4
B	$ 1,596,660.91	$ 1,797,465.93	$ 200,805.02	12.6
C	$ 1,128,209.04	$ 1,271,030.04	$ 142,821.00	12.7
D	$ 1,399,743.18	$ 1,576,324.53	$ 176,581.35	12.6
E	$ 1,514,444.88	$ 1,701,234.32	$ 186,789.44	12.3
F	$ 563,443.32	$ 631,519.08	$ 68,075.76	12.1
G	$ 2,282,811.54	$ 2,550,324.60	$ 267,513.06	11.8
TOTALS	$11,368,117.67	$12,768,981.70	$1,400,864.03	12.3

Class	Normal Speed	1974 Restricted Speed	Cost Increase	Percent Cost Increase
A	$ 882,651.20	$ 995,200.03	$ 112,548.83	12.8
B	$ 445,279.89	$ 513,137.69	$ 57,857.80	12.7
C	$ 352,742.04	$ 397,560.24	$ 44,818.20	12.7
D	$ 547,501.68	$ 617,056.11	$ 69,554.43	12.7
E	$ 631,770.64	$ 712,071.60	$ 80,300.96	12.7
F	$ 294,561.12	$ 331,953.72	$ 37,392.60	12.7
G	$ 1,178,121.06	$ 1,327,858.98	$ 149,737.92	12.7
TOTALS	$ 4,342,627.63	$ 4,894,838.37	$ 552,210.74	12.7
GRAND TOTALS	$15,710,745.30	$17,663,820.07	$1,953,074.77	12.43

Table 25. Ship Incidents Attributable to Velocity or Water Conditions

Ship	Date	Incident - Location
Eirini	5/11/73	Bumped lower wall at Snell
Frankcliffe Hall	5/20/73	Grounded-South Cornwall Channel
County Clare	6/4/73	Grounded-South Cornwall Channel
Lorina	7/6/73	Grounded-South Cornwall Channel
Sugar Producer	7/8/73	Grounded-Copeland's Cut
Dneproges	7/13/73	Grounded-Copeland's Cut
Salvage Monarch	9/12/73	Grounded-Copeland's Cut
Calgadoc	10/4/73	Bumped lower wall at Snell
John E. F. Misener	10/7/73	Bumped lower wall at Snell
M/V Bawn of Kuwait	9/9/73	Bumped lower wall at Snell
Zakarpatye	11/8/73	Grounded-Copeland's Cut
Montrealais	11/8/73	Grounded-Copeland's Cut
Brunneck	11/8/73	Grounded-Copeland's Cut
Elianne	11/11/72	Grounded-Copeland's Cut
Janetta	11/11/72	Grounded-Copeland's Cut

Source: St. Lawrence Seaway Development Corporation, Massena, New York.

This resulted in 1165 hours of lost time or an equivalent loss of $350,000.[5]

Additional actions taken by the St. Lawrence Seaway Development Corporation to minimize the damages associated with low water and high velocity currents were to: (1) prohibit passing or meeting of vessels in the affected

[5]Figures provided by St. Lawrence Seaway Development Corporation. Dollar loss derived by the Corporation using Figures from Table 23.

stretch,[6] (2) reduce speeds of vessels, in accordance with the vessel's individual characteristics to reduce "squat" so as not to strike bottom, (3) instruct Operation Personnel not to fill Eisenhower Lock when vessels in this stretch of the Canal are at or approaching maximum draft, (4) implement "sweeping" operations to determine present river bottom conditions as compared to design grade, and (5) program measures to determine actual velocity conditions in this area.

There are certain additional costs associated with concern, worry, anxiety and possible further reductions in speeds attributed to caution. These costs are incurred as a direct result of the increased hazard potential occasioned by the shallower water and increased currents. These costs were not quantified.

Increased siltation in the St. Lawrence Seaway was not a problem caused by high water due to the fact that the river bed consists primarily of glacial till. A minor problem occurs when wake action erodes banks and causes them to slough. This exposes boulders which, in areas of cuts, have had to be removed. The cost of picking these boulders is not broken out from the general cost of Seaway maintenance. However, it is considered by Seaway personnel to be minor.[7]

3. Riparian Property Owners

The impact of the recently experienced high water levels on riparian property owners can be approximated. Data available provides estimates of damage to man-made facilities. Estimates of damages to the natural environment are not easily quantified. Therefore, these damages will be discussed verbally.

a. Above Moses-Saunders Dam - Data on damages incurred on the United States portion of Lake Ontario are limited primarily to that incurred during the March 17-18, 1973, storm. Through Presidential Disaster Declaration No. 965, seven counties were declared major disaster areas based on Federal criteria. Riparian property owners then became eligible for Federal relief programs. Funds distributed through these various relief programs were used as proxies of damages incurred. Figure 20 shows the erosive forces of nature at work on the Lake Ontario shoreline which inflicted severe damages.

---

[6]The stretch of canal referenced runs to about five miles upstream from the Eisenhower Lock in the Wiley-Dondero Canal. This includes the area known as Copeland's Cut.

[7]Phone conversation with William Spriggs, Director, Office of Operations, St. Lawrence Seaway Development Corporation.

Figure 20. Erosive Forces at Work on Lake Ontario's Shoreline

The Small Business Administration was the primary agency dealing with loans following the declaration of the disaster. Their records reflect that 4,344 home loans amounting to $19,264,855 and 254 business loans amounting to $3,678,900 were granted as of September 24, 1974. This totals to $22,942,755. Table 26 shows the breakdown of these loans by county. Of the amount loaned, approximately 90 percent was in the form of a grant due to the $5,000 forgiveness clause written into the Disaster Relief Act of 1972.[8]

The above data reflects two important points. First, most loans were of relatively small amounts, i.e., less than $5,000 since about 90 percent of the money loaned was covered by the forgiveness clause. Second, the majority of the loans were home loans. It is contended that a large percentage of these home loans were probably for second homes. Figure 21 depicts some of the types of damage that may have been inflicted during the storm period.

Table 26. Numbers and Amount of Loans Resulting from March 1973 Storms

County	No. of Loans	Dollar Amount
Cayuga	114	$ 439,050
Genesee	15	31,700
Jefferson	877	4,287,953
Monroe	1,292	6,999,550
Niagara	702	3,942,950
Orleans	501	2,396,680
Oswego	509	2,153,425
Wayne	476	2,492,300
Others	114	467,300
TOTALS	4,600	$ 23,210,908

Source: Provided by Small Business Administration, Elmira, New York.

Damage to public property is estimated by the claims made by State agencies and political subdivisions for Federal financial assistance under Disaster OEP 367 DR, declared March 21, 1973 pursuant to Public Law 91-606 for flooding as a result of storms during the period March 16-23, 1973. The amounts of these claims are reflected in Table 27.

New York State, Office of Parks and Recreation, provided data on damages to state parks. These data are in terms of budget requests to repair facilities. One million dollars was

[8]This estimate was provided by William McDevitt, Branch Manager, SBA, Elmira, New York.

Figure 21. The Impact is Varied.

Table 27. Applicants for Federal Financial Assistance for Public Property Damage.[a,b]

Public Entity	Assistance Requested ($)[c]
State Agencies	
Parks and Recreation	26,170
SUNY, Oswego	31,185
Oswego Port Authority	127,152
	184,507
Niagara County	
Town of Newfane	6,301
Town of Porter	4,662
Town of Wilson	184,998
Village of Wilson	8,775
	204,736
Monroe County	
County	173,459
Village of Brockport	9,103
Town of Greece	29,810
Town of Hamlin	35,886
Town of Irondequoit	55,200
Town of Parma	37,311
City of Rochester	14,400
Town of Webster	10,453
	365,622
Wayne County	
County	6,726
Town of Huron	15,863
Town of Sodus	8,269
Village of Sodus Point	13,266
	44,124
Cayuga County	
Village of Fair Haven	1,468
Town of Sterling	6,127
	7,595

Table 27. Applicants for Federal Financial Assistance for Public Property Damage (continued)

Public Entity	Assistance Requested ($)[c]
Oswego County	
Town of Mexico	1,975
City of Oswego	92,465
Town of Oswego	7,305[d]
Town of Sandy Creek	4,732
County	9,000
	115,477
Orleans County	
Village of Lyndonville	12,630
	12,630
Jefferson County	
County	24,700
Town of Alexandria	10,600
Village of Alexandria Bay	8,480
Town of Brownville	2,030
Town of Cape Vincent	32,530
Village of Cape Vincent	1,640
Town of Clayton	4,447
Village of Clayton	61,020
Town of Henderson	11,360
Town of Lyme	18,300
Village of Sackets Harbor	20,390
	195,497
TOTAL	1,130,188

[a]As of 20 December 1974

[b]Data based on project applications approved by Federal Disaster Assistance Administration. Applicants in Genesee County not included as this county does not border Lake Ontario.

[c]Data does not necessarily reflect what applicants will receive, because final payment depends on work completed and paid for by applicant, final inspection and audit. Amounts may be decreased in this process.

[d]Town of Oswego will not receive Federal funds because it does not plan to undertake repair work.

Source: Division of Military and Naval Affairs, State of New York, Albany, New York.

requested and $900,000 was budgeted. Of this amount, $660,000 was required for "reconstruction of various parks and recreation facilities damaged by storms and flooding, and construction of storm protection devices... due to storms and high level of Lake Ontario.

Genesee Region.....150,000
Niagara Region.....200,000
Central New York Region.....270,000
Thousand Islands Region..... 40,000"[9]

A representative of the Office of Parks and Recreation states, "Additional losses such as property erosion, silting of channels, etc. are rather poorly covered by these estimates."[10]

In total, approximately 25 million dollars worth of federal aid was requested by riparian owners of the New York portion of Lake Ontario and the St. Lawrence River. This figure can be used as an estimate of the damage sustained by man made facilities in this area during the short period of mid-March 1973.

Estimates of damage to man made facilities sustained on the Canadian portion of the shoreline are not available at this time. Currently the Canadian government has underway a study, The Canada/Ontario Great Lakes Shore Damage Survey Report, which will evaluate damages due to high water for the period November, 1972 to November, 1973. It is expected to be completed in November, 1974 (see Appendix A).

b. Below Moses-Saunders Dam - Significant impact to riparian owners below the Moses-Saunders Dam is limited primarily to the area around Montreal.[11] Negative impact occurs when the combined flow of the Ottawa River and the St. Lawrence River exceed 500,000 cfs.[12]

---

[9]New York State Supplemental Budget, 1973-1974, Chapter 600.

[10]Letter from Ivan Vamos, Director, Planning and Research, New York State Office of Parks and Recreation, dated August 27, 1974.

[11]The area sensitive to flooding where major damage occurs is below Beauharnois and above the Lachine Rapids. Flooding in Montreal Harbor when it does occur is primarily due to ice jams.

[12]The 500,000 cfs refers to the combined flow of the Ottawa River, prior to its splitting upstream of Montreal, and the St. Lawrence River, prior to its confluence with the Ottawa River. In other terms flooding on Lake St. Louis occurs when the outflow from the Lake exceeds 380,000 cfs (provided by Canadian Regulation Representative and IJC) including the contribution from the Ottawa River. A figure of 345,000 cfs was provided by the St. Lawrence Seaway Development Corp.

The primary causes of damage are backwater from the Ottawa River in the Lake of Two Mountains area and flooding in the Three Rivers area. Montreal Harbour itself experiences little flooding.

Again, no data were available upon which total damages could be determined. Estimates of damages in the Montreal Region are 10-15 million dollars in 1974 and less than 6 million in both 1972 and 1973. It is estimated that about 25 million dollars occurred in the entire province of Quebec in 1974.[13]

It is understood that the Canadian federal and provincial governments are currently studying the problem of flooding on the Ottawa River, examining Ottawa River regulation and developing the stage - damage relationship for the Ottawa River and Montreal Harbour area.

c. Natural Environment - Assessment of the impact of the high water levels on the natural environment of Lake Ontario and the St. Lawrence River had to be acquired through field observation since no published sources could be located that report such data. Negative impacts are observed in the form of bluff erosion, sand dune erosion and general beach erosion at rates that appear to be in excess of the historic rate. River mouths clogged with sediment deposits are another example of the impact. Destruction of vegetation, including mature trees, indicates the severity of the erosion. Figures 22 and 23 depict examples of damage to the natural environment along the New York portion of Lake Ontario.

Figure 24 depicts the changing barrier beach configuration of North Sandy Pond, Oswego Co., New York, for the period 1938 to 1973. Figure 25 shows an aerial view of the beach in June 1974. As can be seen, the high levels in the past few years have accelerated the rate of erosion of this sand barrier beach.

No estimate of the impact of this destruction on the natural environment of the area has been made to date by federal, state or local governments. Efforts are now underway by the United States Army Corps of Engineers to partially examine this along with other aspects of shore damage (see Appendix A).

---

[13]Estimates provided by Mr. R. Pentland, Department of Environment Canada.

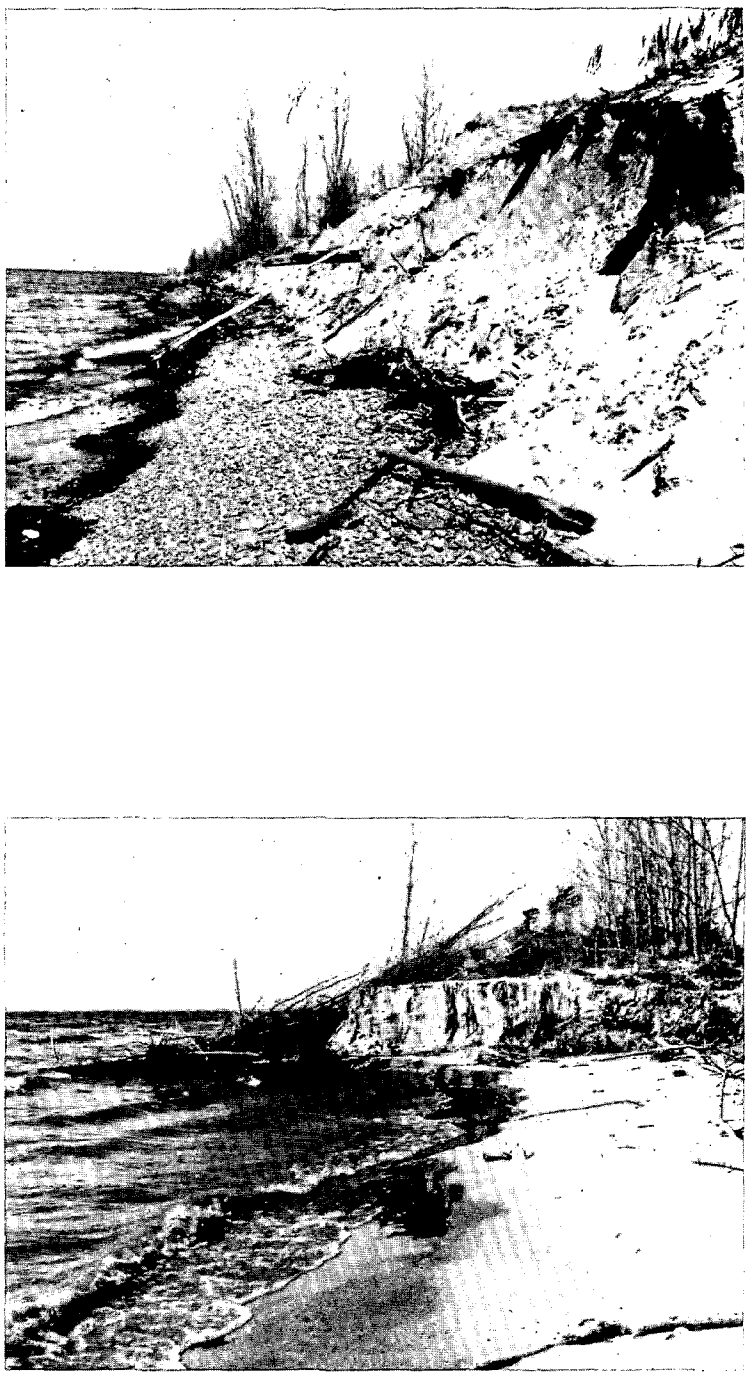


Figure 22. Destruction of the Natural Environment - Lake Ontario.

Figure 23. Accelerated Erosion - February, 1973 (top photo) March, 1973 (bottom photo).

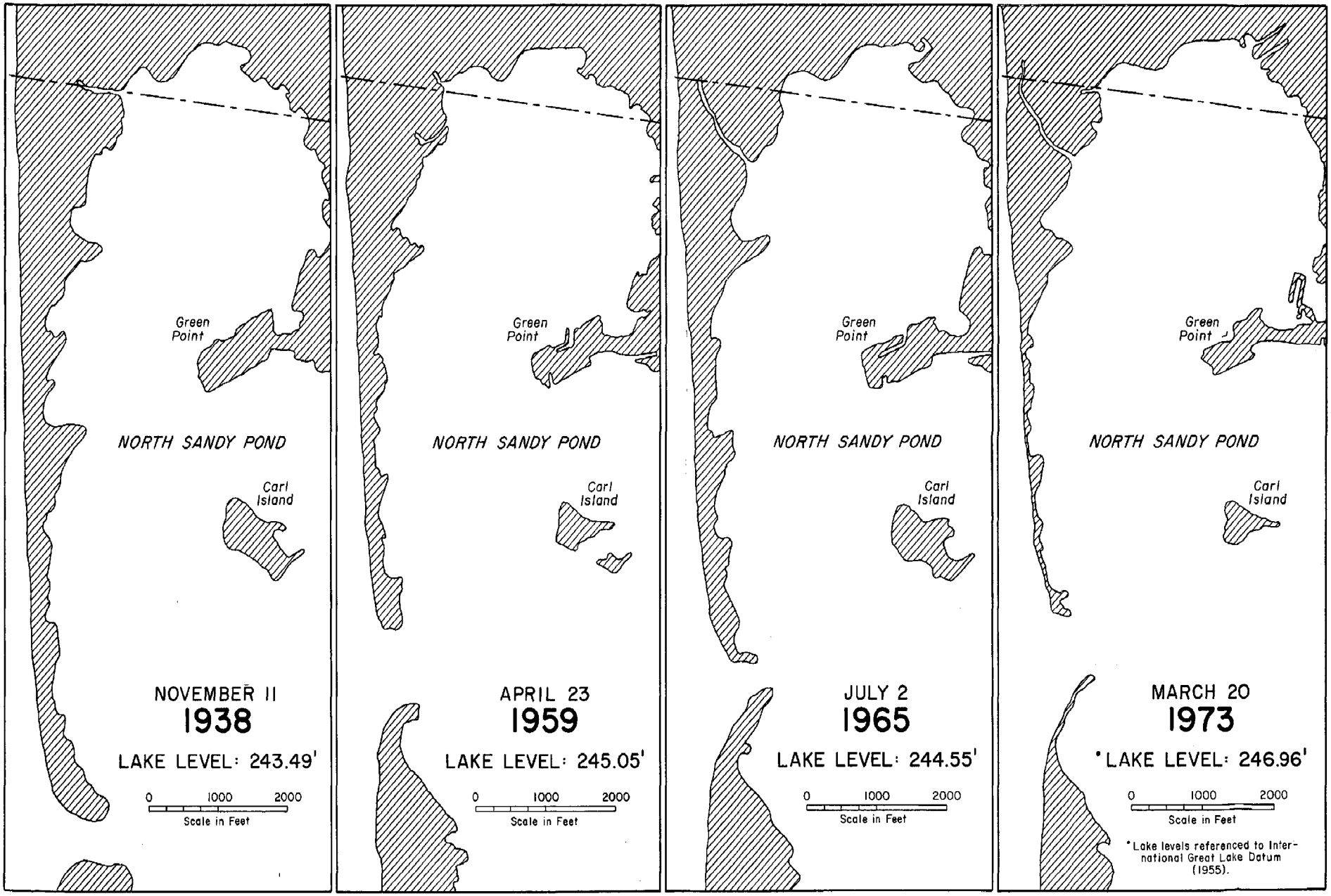


Figure 25. North Sandy Pond: Barrier Beach Configuration Sequence, 1938 - 1973.

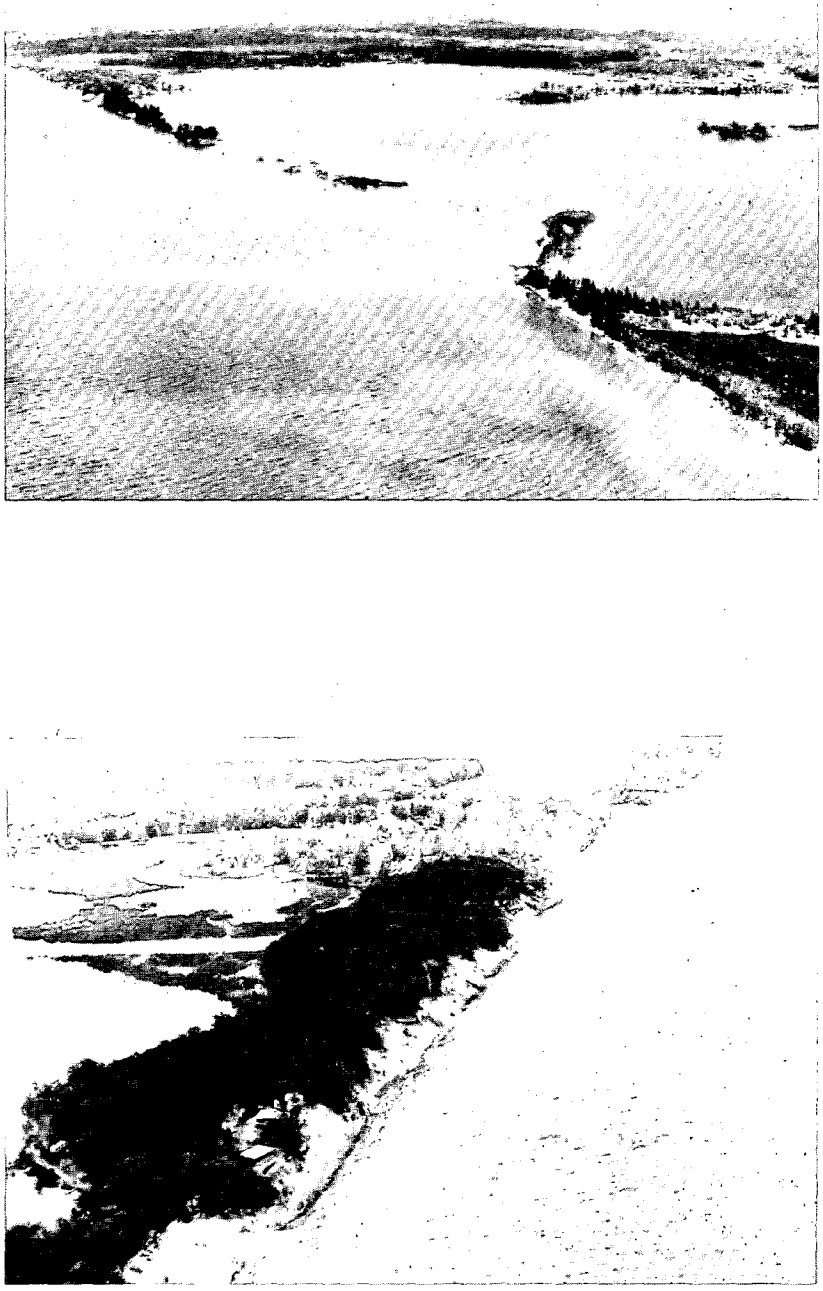


Figure 25. North Sandy Pond: Barrier Beach Configuration, June, 1974.

On the positive side the high water may have helped water quality in many locations, as well as increasing the productivity of adjacent wetlands by providing improved conditions for nesting and spawning during critical periods. It may also have allowed the postponement of dredging operations in some harbors and rivers. This impact in terms of dollars was not determined.

In summary, evaluation of the impact of the high water levels on the natural environment of Lake Ontario and the St. Lawrence River has been given almost no consideration. Effects on fish spawning beds, wetlands, erosion rates, littoral drift rates, etc. have been left unstudied. Without this information, man's efforts to control the levels of the Lake are at best biased - biased toward other interests for whom impacts can be and are quantified.

B. Evaluation of Impact

Following is a brief summary of the magnitudes and incidences of impacts of the high water levels on Lake Ontario and the St. Lawrence River described above. Table 28 reflects whether the magnitude was small, moderate or large and whether it was positive (+) or negative (-). Positive impacts are synonomous with benefits and negative impacts with damages. The incidence of the impact is broken down by the three major interest groups - power, navigation and riparian owners - and then into subgroups of these.

As can be seen the majority of the impacts have been negative except for the power interest. Of these negative impacts the magnitude has been large only for riparian owners where properties above Moses-Saunders Dam, and properties below Moses-Saunders Dam have been inflicted with large negative impacts. Although the total impact on the natural environment is felt to be negative the magnitude is at this time indeterminate. Only increased revenue for power interests can be classified as a large positive impact.

If the quantifiable impacts were summed, the total would be negative for the period January 1973 through August 1974. This sum would not reflect a true picture of the absolute impact, however, since some negative impacts - damage to the natural environment - are not quantifiable. However, it would reflect the fact that the impact has been negative in total with riparian owners bearing the brunt of the impact.

In general terms, it can be stated that the releases from Lake Ontario were made in accordance with the requirements of the Order of Approval, as reflected through Plan

Table 28. Magnitude and Incidence of Impacts of High Water Levels

Incidence	Magnitude[a] Small	Moderate	Large
Power			
Increased Revenue			+
Rebate to Customers		+	
Navigation			
Increased Operating Cost		-	
Damages	-		
Riparian Owners			
Above Moses-Saunders Dam			-
Below Moses-Saunders Dam			-
Natural Environment[b]			

[a] + indicates a positive impact
- indicates a negative impact

[b] The net impact is felt to be negative. However, the magnitude is at present indeterminate.

Of Control 1958-D, and as modified by the actions of the St. Lawrence River Board of Control. Under the circumstances this resulted in a minimization of the navigational hazard; a substantial gain for the power interests; and inflicting of severe damages on the riparian owners and natural environment.

CHAPTER V

DAMAGE REDUCTION TECHNIQUES

Methods of reducing damages to property on or adjacent to the lake flood plain are classified into three general groups - regulation of the lake water levels, shore protection measures and flood plain management. Combinations of any of these methods are also often feasible. Each method will be described below along with its limitations and strengths.

A. Types of Damage Reduction Techniques

1. Regulation of the Water Level

Regulation infers some degree of control. As used here, it relates to control of the water levels of a lake. A regulation plan is a means of determining the flow out of a lake for a given future period. A plan, very simply, is normally developed by routing known past water supplies through the system such that a more favorable level and flow regimen is achieved than would occur if the system was left uncontrolled. The routing sequence that comes closest to achieving the desired results is then incorporated into the plan of control. It is utilized under similar supply conditions in the future.

Regulation of any lake generally requires two basic facilities: first, one or more control structures capable of reducing the outflow, especially when low lake levels occur, and second, dredging of its outlet river so that greater flows can be released at times when high lake levels occur.

Regulation of water levels is limited to a degree by the drainage area of the system to be controlled. To be fully effective, the control structure(s) have to be capable of reducing the outflow under extreme supply conditions while the channel modifications have to be extensive enough to allow passage of high supplies. In the case of the St. Lawrence River, the outlet for the entire Great Lakes System, any control device located on it would have to be capable of controlling the waters discharged from about 95,000 square miles of water area and approximately twice as much land area.

The costs incurred in building a system meeting these criteria are usually high, both from an absolute dollar and an environmental point of view. Thus, most existing systems of this type are not built to control the extremes in supplies, but only a range in the middle, leaving damages to occur at both ends of the supply scale. Other limitations of this method of control are that the operating criteria and structures are usually developed to meet a given set of conditions. Over time these conditions change. It is often not possible - either physically or insitutionally - to change the regulation procedures rapidly enough to keep pace with such changes. Man's inability to accurately forecast weather - both short and long term - is also a constraint on the efficient operation of a regulatory system.

In general, regulatory plans are effective for the range of supplies for which they were developed. However, this range is usually less than the range in water supplies that can be reasonably expected to occur.[1] Thus the extremes of the expected range are left uncontrolled and when they are experienced, large amounts of damage normally occur. This is particularly true of high water supply conditions.

2. Shore Protection Measures[2]

Protection measures are generally built for the purpose of preventing recurrence of damages to shore property, including measures to prevent damage from erosion and wave action, and measures to prevent damage from inundation.

Shore protection methods may be divided into three basic types: (1) those that provide protection by means of a higher beach, (2) those that shield vulnerable portions of the shores from the forces of waves and (3) those that reduce or prevent flooding of lower adjacent lands behind such protective structures.

Below is a description of several commonly used protection structures and a discussion of their effectiveness. Each of the different types of shore protective

---

[1]As used here "reasonably expected" is that evaluation made based on statistical analysis of past supplies. As an example of its usage consider the fact that the Corps usually builds flood protection levies to provide 100 year protection, if economically and technically feasible, even though flows in excess of the magnitude of 100 year flows are "reasonably expected".

[2]This section is adapted from: Great Lakes Shoreline Damage, Causes and Protective Measures, U. S. Corps of Engineers, North Central Division, May, 1972.

structures has its own inherent advantages, disadvantages and limitations. These attributes generally dictate the method to be employed and the degree of protection to be achieved. In some instances, they provide an indicator as to what not to do, as well as what should be done. Appendix B lists several publications dealing with shore protection measures.

Bulkheads, seawalls and revetments differ only in their primary function. By definition, a bulkhead is a structure separating land and water areas, primarily designed to resist earth pressures; a seawall is also a structure separating land and water areas, primarily designed to prevent damage to an upland area while retaining its seaward limit in a fixed position. A seawall may also be designed to resist earth pressure. A revetment is a facing, generally of stone, built to protect an otherwise stable embankment against erosion from wave action (see Figure 26).

The principal advantages attributable to bulkheads, seawalls and revetments are: (1) they provide positive protection and generally permit more intensive use of the adjacent upland; (2) they maintain the upland area on a fixed alignment, and (3) they are adaptable to providing protection to an area with a minimum of incidental damage to adjacent areas. Disadvantages of bulkheads, seawalls and revetments are: (1) they are not effective in maintaining a beach; (2) they provide no protection to adjacent areas which may continue to erode and eventually expose the flanks of the protected property.

Groins provide upland protection by intercepting part of the granular material that is moved along shore by wave generated currents. Their principal advantages are: (1) the resulting beach provides protection to upland areas as well as a potential recreation area; (2) their effect may spread over considerable lengths of shore; and (3) at those locations where groins would be effective, protection can generally be provided at lower initial cost by their use. Disadvantages in the use of groins include: (1) they are not as positive as a seawall for continuous upland protection; (2) they may be outflanked; (3) they are ineffective in areas of low littoral drift unless granular beach fill is artificially added and (4) the area immediately downdrift of the groin may be subject to increased scour.

Offshore breakwaters provide protection to upland property by reducing the wave energy impinging on the shoreline. Submerged breakwaters are a type of offshore breakwater and have the same general effect depending on depth of submergence. These may also be used to reduce

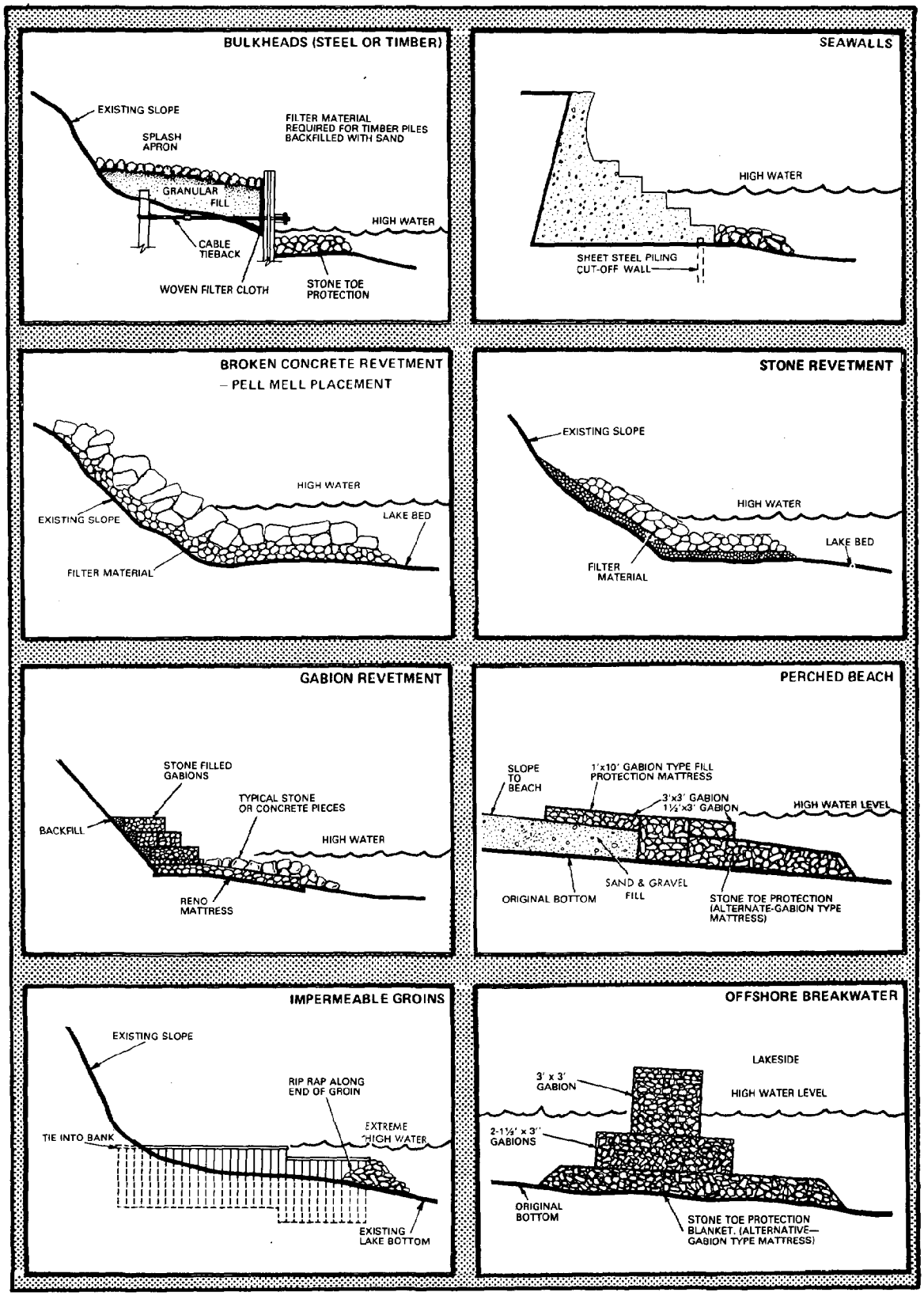


Figure 26. Schematic of Shore Protective Devices (Source: Help Yourself, Dept. of the Army, Corps of Engineers, North Central Division)

beach slopes artificially, and thus prevent loss of material. The principal advantages are that: (1) they provide protection without impairing the usefulness of the beach; and (2) they may provide sheltered waters for boating. Disadvantages are: (1) the relatively high cost of construction; (2) they protect only the shore behind them and for a short distance updrift; and (3) they may cause downdrift erosion.

A beach fill protects the upland by interposing a width of beach between the upland and the lake to absorb wave energy. The advantages of protection by beach fills are its pleasing appearance and possible recreational value. The principal disadvantages are that they require an adequate supply of beach material economically located and continuous maintenance must be provided.

3. Flood Plain Management

Flood plain management can be considered an affirmative, preventive measure in that it places constraints on man's activities in flood plain areas. Thus flood plain management can prevent man, to varying degrees, from encroaching on the flood plain and therefore from experiencing damages incurred by flooding caused by storms or high water levels.

Management techniques are numerous and are implementable at various levels of government. Some of the more common techniques are discussed below.

a. Land-Use Planning - Many cities, towns and villages have planning boards empowered to develop plans for sound future land use. Only the larger municipalities have the financial ability to employ professional staffs for these boards. Smaller municipalities, even with federal planning aid available, must rely on consultants to produce their plans. The usefulness of these plans is limited by the lack of staff to keep them current and to apply them to specific implementation techniques.

b. Zoning Ordinance - Cities, towns and villages are empowered to adopt zoning ordinances and to control flood plain land use within these ordinances. The limitations of staff which restrict planning also restrict the effectiveness of zoning. In addition, the relatively small geographic area of many municipalities may mean that they are frequently subject to flooding caused by stream encroachment outside their jurisdiction. Flood plain zoning in such cases may be ineffective unless adopted in concert by adjoining municipalities.

Flood plain zoning requires technical information and engineering skill beyond that required for other types of zoning. Also, public pressure on a local zoning board can be very great. Exceptions and variances are common and can destroy originally sound controls. It has been observed that zoning works fine until it is readlly needed. When the pressures of urbanization and recreational development become most critical, zoning becomes most vulnerable.

c. Subdivision Regulation - Planning boards can deny subdivision approval in areas deemed hazardous to public health and safety. Subdivision rules may require that the land be suitable for building sites and of such character that it can be used safely for building purposes without damages to health or peril from fire, flood or other menace. To use this power effectively, flood hazard areas must be delineated on a map.

d. Public Utility Policy - Communities may seek to direct development away from flood plain areas by limiting the provision of public water and sewer services in these areas. In some areas this has been the subject of formal policy resolution by the municipality. This is an indirect technique. Unless firmly determined upon, it will be weak when confronted with pressures for service in these areas.

e. Building and Health Codes - These codes regulate the type of construction and the provision of adequate sanitary facilities to protect the health and safety of the inhabitants. Additional cost may be involved in meeting these regulations in hazard areas such as flood plains, but if the developer is willing to meet these costs, the codes will not prevent him from building there. Code requirements should not be set arbitrarily high merely for the purpose of preventing development.

f. Official Map Technique - Municipalities may adopt an official map identifying the right-of-way or boundaries of future streets, highways, public building sites, storm drains or parks.

The official map serves as a regulatory tool; the municipality may deny permits for the erection of any building in a proposed street or other future public area shown on the official map. This prevents speculation construction for gain in areas which have been officially declared necessary for future rights-of-way. Private property owners thus restricted must be compensated by tax relief and/or public purchase of the required property. The law is inconclusive as to whether this authority can be exercised within drainage ways. Although it permits drainage ways to be shown on the official map, the official map is little used because of legal uncertainties about its

operation relative to flood prone areas. It is also the subject of variances where the owner can demonstrate "hardship".

g. Land Purchase - Municipalities can acquire flood plain land and use it for parks, playgrounds and other relatively damage-free uses. This is recommended in numerous land-use plans, but is not frequently carried out.

Several problems stand in the way of large scale municipal land acquisition. Even with state and federal aid, the local share of purchase cost may be large in proportion to community tax resources. The municipality may also be unwilling or unable to take land off the tax roles.

h. Development Right Purchase - This is authorized but remains basically an untried tool at the local level. Some states have used this tool to maintain scenic easements along highways or rivers. The advantage over free-simple purchase is, in theory, its lower cost, but experience indicates that this saving is only significant in undeveloped rural areas where pressures for development are smallest. Where most urgently needed purchase of development rights will generally approximate the total value of the property.

i. Easement Purchase - This could be used to acquire narrow drainage easements in developed area but would be less applicable to the area of a large coastal flood plain.

j. Information - Information is usually provided by a high - state or federal - level of government. Currently the Corps of Engineers, United States Geological Survey, Soil Conservation Service and the National Weather Service all provide information relative to existing or impending flood hazards, either in the form of delineation of existing hazard areas or in the form of warning of an impending hazard.

The ten techniques discussed above yield best results when utilized in a coordinated manner. The degree of success of almost all depends upon the degree of resolution with which they are implemented or enforced.

k. Flood Insurance - Another measure that can be utilized is flood insurance. This technique does not reduce damages but changes the incidence of the damage over time and as to who bears the financial burden. This program is administered by the Flood Insurance Administration, Department of Housing and Urban Development. Requirements for eligibility have the potential to reduce future damages incurred by flooding. These requirements include implementation of some of the above listed management

techniques, for example, zoning ordinances, building codes and the provision of information on the degree of flood risks. See Appendix C for a summary of the Flood Insurance Program.

The following chapter will discuss the degree to which the above methods of reducing damages have been implemented in the Lake Ontario - St. Lawrence Basin.

B. Applicability

The three damage reduction techniques described above are not uniformly applicable along the Lake Ontario and St. Lawrence River shoreline. The choice of technique to provide the protection required is limited under certain conditions. These limitations are discussed as they relate to protection of both man made facilities and the natural environment.

1. Man Made Facilities - Limitations to the type of damage reduction technique utilized to protect man made facilities are numerous. They are listed below and described in general terms.

a. Economic - Structural protective devices provided by governmental agencies must meet rigorous economic criteria. The inability to do so often limits the use of this technique.

b. Ownership of property to be protected - Public funds are restricted in their use to provide protection for private property. Thus, the use of certain structural protective devices is limited by the ownership pattern of the land to be protected.

c. State of development of shoreline - Flood plain management techniques are often not applicable in areas where development has occurred. In such areas, protection is limited to lake level regulation and structural protective devices.

d. Scale - Lake level regulation is applicable only to the entire lake. Thus, segments cannot be regulated by individuals or groups. Effectiveness of structural protective devices generally are limited by scale also. Such devices as seawalls, bulkheads, revetments, etc., protect shore reaches of shoreline, and when built by individuals in an uncoordinated manner are usually not effective in reducing overall shoreline damage.

2. Natural Environment - Protection of the natural environment - sand dunes, beaches, wetlands, marshes, etc. - is generally restricted to lake level regulation. Structural

protective devices are generally not appropriate for use in such areas; they often have the effects of limiting access to the area, imposing upon its aesthetic quality, adversely altering along shore currents, or otherwise damaging its "natural" qualities. Flood plain management techniques prevent man from encroaching upon the natural hazard areas and thus from incurring additional damages to man made facilities. However, such techniques do not protect the natural environment itself from the damages caused by changes in water levels. Only lake level regulation can provide the protection that is required for the natural environment.

In summary, it can be said that techniques suitable to protect man made facilities, although limited, are more flexible than those suitable for protecting the natural environment. For the latter, only lake level regulation seems to provide the protection desired without destroying the area to be protected.

CHAPTER VI

DAMAGE REDUCTION METHODS IMPLEMENTED IN THE GREAT LAKES BASIN

Currently all of the methods of reducing damages discussed in the preceeding chapter are being utilized within the flood plain bordering Lake Ontario. In some areas, combinations of the three general methods are used. Due to the nature of the control plan and structural works for regulating Lake Ontario water levels, all flood plain areas are influenced and "protected" to some degree by the control afforded by the operation of the plan and its associated regulatory structures.[1]

A. Water Level Regulation

Currently there are two plans of regulation in operation on the Great Lakes. Both have been designed to satisfy certain criteria set forth in Orders of Approval of the International Joint Commission.[2]

1. Plans of Regulation Within the Great Lakes

a. Lake Superior Regulation - Since completion of the control work on the St. Marys River at Sault Ste. Marie in August, 1921, the outflows from Lake Superior have been subject to complete control. The Lake is regulated in accordance with the Orders of Approval of the International Joint Commission issued May 26 and 27, 1914, in reply to applications for authorization of diversions of water around the rapids for production of power. The Orders provide that the works be so operated as to maintain the lake levels within a specified range and not to interfere with navigation.

---

[1]Even in periods of high water when damage is occurring, the U. S. Army Corps states that the damage would be greater without operation of the control plan due to the fact that the water level would be higher if there were not control structures and a plan of regulation (See Figure 29).

[2]The International Joint Commission works within the framework established as a result of passage of the Boundary Waters Treaty of 1909 between the United States and Canada.

Further, they provide safeguards against extremely high and low regulated lake levels, and high levels on the St. Marys River. The International Lake Superior Board of Control established by the Commission in accordance with the terms of its Order directly supervises operation of the river control works and the amount of the diversions. Details on the regulation plans used for Lake Superior can be found in the Great Lakes Basin Framework Study.[3]

b. Lake Ontario Regulation - The regulation of Lake Ontario began in April 1960 in accordance with the International Joint Commission's Order of Approval of October 29, 1952, and the Supplementary Order of July 2, 1956, and is under the direct supervision of the Commission's International St. Lawrence River Board of Control. Appendix D provides the office consolidation of the Orders of Approval.

The orders provide that the lake is to be regulated during the navigation season within a certain range of levels and to meet certain additional requirements relating to downstream interests, to power interests, and to other Lake Ontario interests. These requirements are set forth in Criteria a-k listed in Appendix D.

2. Organization For Regulation

On January 11, 1909, the United States of America and Canada entered into a "Boundary Waters Treaty." Appendix G provides the text of this treaty. The purposes of the treaty as set forth in its preamble are:

a. to prevent disputes regarding the use of boundary waters;

b. to settle all questions pending between the United States and Canada involving the rights, obligations or interests of either in relation to the other, or to the inhabitants of the other, along their common frontier; and

c. to make provision for the adjustment and settlement of all such questions as may hereafter arise.

Article VII of the "Boundary Waters Treaty" established the International Joint Commission (IJC). The International Joint Commission, in carrying out the purposes of the Boundary Waters Treaty of 1909, has wide-ranging responsibilities with respect to boundary waters between the United

---

[3]Great Lakes Basin Framework Study, Appendix 11, U. S. Army Engineer Division, North Central, September, 1972.

States and Canada. The first of these responsibilities is to approve or disapprove all proposals for use, obstruction or diversion of boundary waters on either side of the boundary which would affect the natural level or flow of the boundary waters on the other side.

Projects may be brought before the IJC by what is termed an "application" filed by interested persons - either public agencies or private corporations or individuals. Examples in the Great Lakes system include the regulatory works at Sault Ste. Marie and those on the St. Lawrence River. In the case of an application for Commission approval, the burden is on the applicant to furnish all necessary information and data required.

The second general responsibility of the IJC is to investigate and make recommendations on specific problems referred to by either or both Governments. The procedure is to submit problems through the United States Department of State and Canada's Department of External Affairs. In the case of references to problems, the IJC appoints an international board which is directed to make a thorough investigation of the facts involved and file a written report. The report of the Commission is then prepared, including recommendations to the two Governments.

On October 7, 1964, during a period of critical low levels on the Great Lakes, the Governments of Canada and the United States requested the IJC to study the factors which affect the fluctuations of the Great Lakes waters. The Governments also asked the Commission if it would be practicable and in the public interest to regulate further the levels of the Great Lakes to reduce the range of stages experienced in the past.

In December of 1964, the IJC established the International Great Lakes Levels Board (IGLLB). This Board, with its working committee and six subcommittees, has been engaged in a joint Canada-United States study to "determine whether measures within the Great Lakes Basin can be taken in the public interest to regulate further the levels of the Great Lakes or any of them and their connecting waters so as to reduce the extremes of stage which have been experienced, and ... for the purposes of bringing about a more beneficial range of stage for, and improvement in: (a) domestic water supply and sanitation; (b) navigation; (c) water for power and industry; (d) flood control; (e) agriculture; (f) fish and wildlife; (g) recreation; and (h) other beneficial public purposes."

The International St. Lawrence River Board of Control (SLRBC) was established (as noted above) with responsibility for determining the outflow rate from Lake Ontario on a weekly basis (see Figure 27). In addition it is responsible

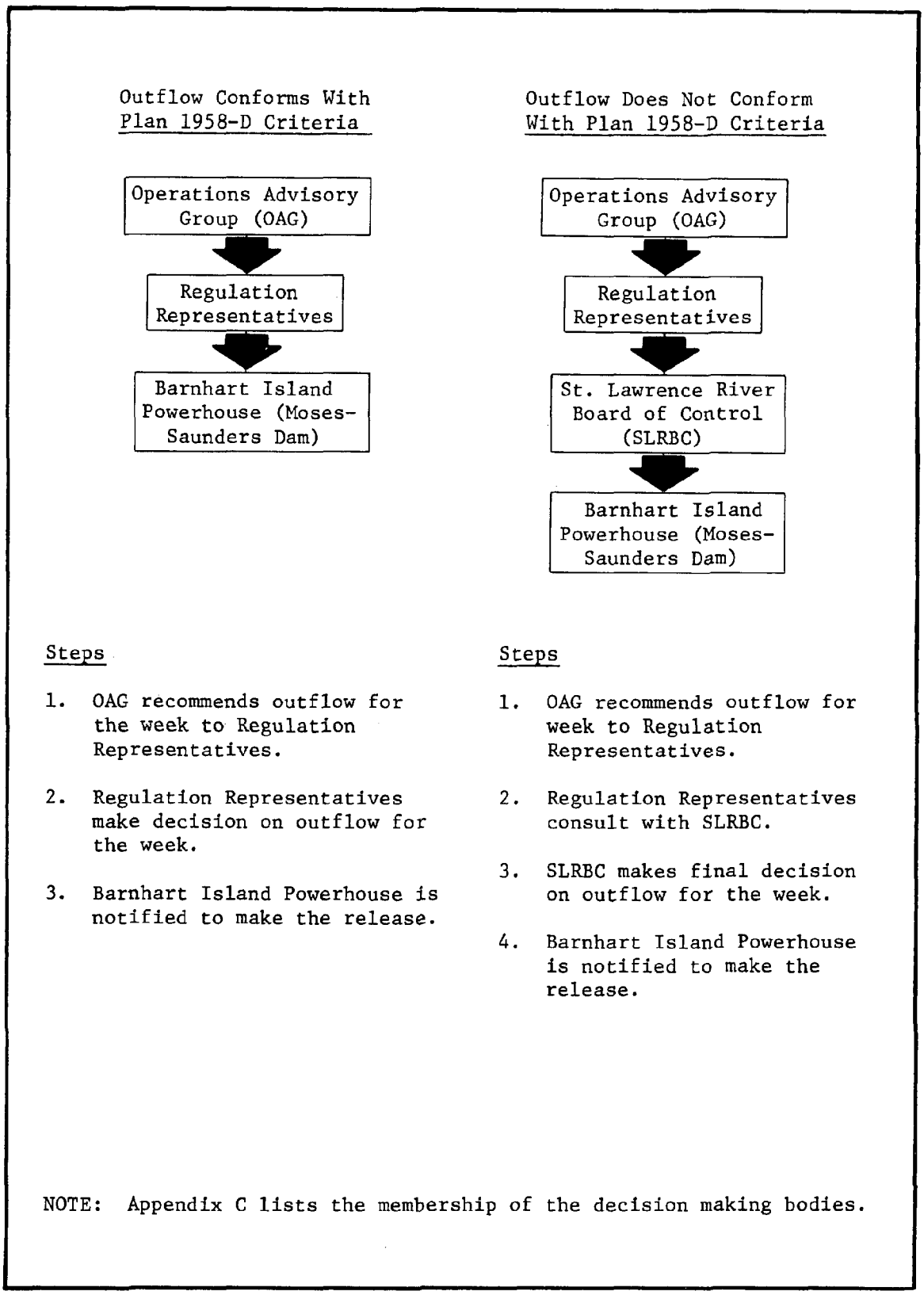


Figure 27. Decision Makers in Regulation of Lake Ontario's Outflows.

for continually improving the means of regulations and has periodically revised the plan of operation. The last major revision occurred in 1963 when Plan 1958-D was adopted and placed into effect in October of that year. Appendix G lists the members of the various organizations described above. Appendix E provides a description of Plan of Control 1958-D.

3. Existing Regulatory Works

The flows in the St. Lawrence River, the natural outlet of Lake Ontario and the Great Lakes, are regulated by a series of structures and an associated channel enlargement (see Figure 28). Between Lake Ontario and Lake St. Louis, where part of the Ottawa River joins the St. Lawrence, there are structures at Points Rockway-Iroquois, at Massena-Cornwall, at Coteau Landing and at Beauharnois. The Moses-Saunders Power Dam and Long Sault Dam at Massena-Cornwall normally control the levels of Lake Ontario, while the series of dams near Coteau Landing, together with the Beauharnois power plant, control the levels of Lake St. Francis.

The Iroquois Dam, which extends 1,980 feet from Point Rockway in the United States to the Canadian shore near Iroquois, was designed with the capability to pass and control, as required, the full discharge from Lake Ontario. Two 350-ton travelling gantry cranes operate the 32 steel, roller-type, sluice gates. Elevation of the top of sills is 200.0 feet. The gates can be dipped to prevent excessive build-up of water levels in Lake St. Lawrence during periods of strong westerly winds. The pattern of gate settings for the dam was developed from hydraulic model tests, and has been selected so as to minimize adverse currents in the navigation channel at the lower approach to Iroquois Lock. The gates are also used during ice formation to assist in promoting a stable ice cover.

Long Sault Dam is located below the foot of Long Sault Island, about 25 miles downstream of the Iroquois Dam, and lies entirely within the United States. It is capable of discharging a flow of up to 450,000 cfs. It measures 2,960 feet along its curved axis and comprises a sluiceway section and a non-overflow section. Thirty 50-foot sluiceways, formed between 10-foot piers, discharge flows in excess of requirements at the Moses-Saunders plants and affect control of river flows and water levels within specified ranges. Eighteen of the thirty sluice gates are equipped with fixed electric hoists, while the other twelve are handled by service cranes on the deck. Two 275-ton electric travelling gantry cranes, running on tracks the length of the deck, provide hoisting service. The spillway crest elevation is 217.0 feet. The gates of

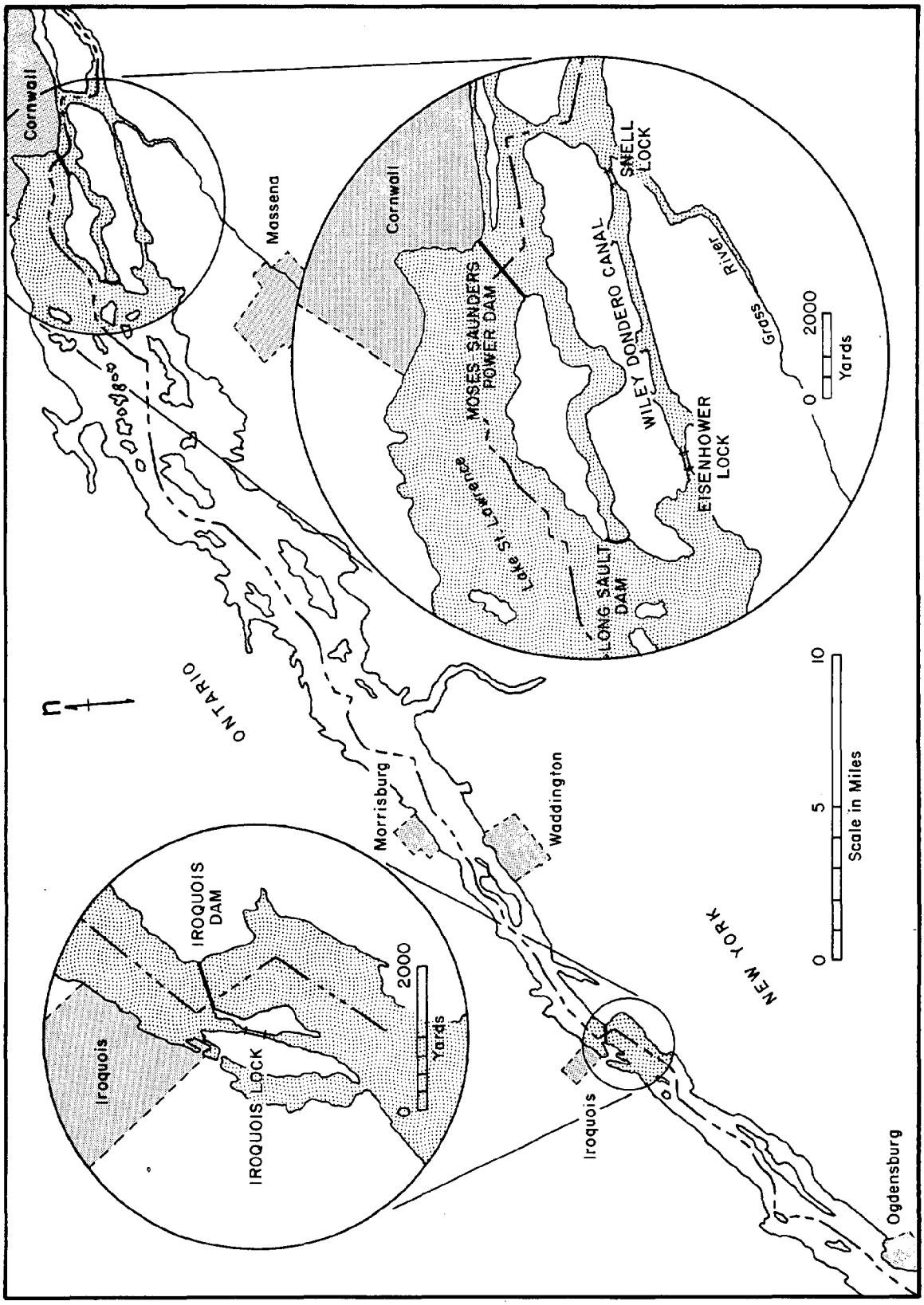


Figure 28. Existing Regulating Works - Lake Ontario and the St. Lawrence River

this dam are operated only under very high river flow conditions or when flows are restricted through the powerhouses for maintenance of generating units.

Located about three and one-half miles downstream from Long Sault Dam and two miles west of Cornwall, Ontario, the Saunders Generating Station of the Hydro-Electric Power Commission of Ontario and the Moses Power Dam of the Power Authority of the State of New York form contiguous power plants spanning the St. Lawrence from Barnhart Island in the United States to the Canadian shore. Bisected by the International Boundary Line, the semi-outdoor plants have a combined length of 3,300 feet with a rated head of 81 feet, and a total flow capacity of approximately 325,000 cfs. With thirty-two 57,000 kilowatt capacity generators, equally divided between Canada and the United States, the combined power plants have a total rated capacity of 1,824,000 kilowatts, making the installation one of the largest hydroelectric power producing plants in the western world. Impounded behind the concrete gravity dam of the power plants is the water of man made Lake St. Lawrence with a volume of 750,000 acre-feet at the normal lake level elevation of 241.0 feet. The lake has an area of 37,500 acres and extends upstream to Iroquois Dam. It is confined by a system of earth embankments at the lower end totalling about 16 miles in length.

At the lower end of Lake St. Francis, about 32 miles east of Cornwall, Ontario, the major part of the St. Lawrence flow is diverted through a 15-mile navigation and power canal to Hydro-Quebec's generating station at Beauharnois. Constructed in three stages over a period of thirty years, the Beauharnois Power House has 36 main generating units with a total capacity of 1,574,000 kilowatts at a head of 80 feet of water. The length of the structure is 2,836 feet and has a maximum discharge capacity of 270,000 cfs. The remainder of the flow leaves Lake St. Francis through the Coteau Control Dams which have a maximum discharge capacity of 435,000 cfs and are utilized by the 162,000-kilowatt Hydro-Quebec generating station in the natural channel of the St. Lawrence River at Cedars. The navigation channel is situated along the north bank of the Beauharnois Canal and has a minimum depth of 27 feet, over a width of 600 feet. Two locks at its confluence with Lake St. Louis allow ships to enter the canal.

An integral part of the St. Lawrence Seaway-Power Project was the St. Lawrence River channel dredging and excavations carried out for the following purposes: (1) to provide a channel depth, width, alignment and water velocity for 27-foot depth navigation; (2) to reduce velocities to induce ice over most of the river thus minimizing operational problems and enhancing the channel

carrying capacity of the river subsequent to the ice forming period; (3) to distribute the flow in such a way as not to interfere with navigation; and (4) more important from the standpoint of lake regulation, to reduce head losses at specific points in order to increase the channel capacity and to maximize the head available for hydroelectric power generation. For the most part, channel enlargements carried out for one interest were beneficial to the other interests.

The International Joint Commission, in its Orders of Approval, specified that the power entities were required to undertake channel enlargements which would ensure that acceptable velocities are provided through the Galop Rapids, particularly below Galop to Morrisburg. These velocities were not to exceed 2.25 feet per second in order to form an ice cover during the winter. Additionally, minimum depths required upstream and downstream of Iroquois were 29.5 feet and 28.5 feet respectively. The power entities carried out channel enlargements in ten areas while the navigation agencies carried out dredging in four locations. The principal locations of channel enlargements carried out by the power entities were at Chimney Island, Galop Island, Lalone-Lotus Islands, Sparrowhawk Point - Toussaints Island, Iroquois, Pt. Rockway, Point Three Points, Ogden Island, the headrace of Long Sault Dam and the trailrace of the Moses-Saunders Dam. The principal locations of channel improvements carried out specifically for navigation were at the Thousand Islands Section in the International Rapids Section at Iroquois Lock, Wiley-Dondero Ship Channel, including Eisenhower and Snell Locks, and in the North and South Channels, adjacent to Cornwall Island.[4]

A total of approximately 107 million cubic yards of material was excavated. The excavations carried out by the power entities totaled 63 million cubic yards; the major locations being in the vicinity of Sparrowhawk Point - Toussaints Island (12 million), Galop Island (16 million) and Point Three Points - Ogden Island (11 million). The excavations carried out by the navigation agencies totalled 44 million cubic yards, with the principal locations being Wiley-Dondero Channel (25 million), and north and south of Cornwall Island (15 million).

4. Evaluation of the Implementation of the Plan of Control During the Current Period of High Water

[4]The Wiley-Dondero Canal was excavated principally through the U. S. mainland and did not affect the hydraulic capabilities of the river channels.

The following evaluation of the implementation of the Plan of Control during the current period of high water is based primarily on the results achieved. Granted, this allows the opportunity for hindsight to be utilized and criticism to be rendered based on the knowledge gathered over time. However, the additional information forthcoming during the time period January, 1973 through August, 1974, provided little of significance beyond what was known to be the situation prior to this time period. No natural phenomena, other than above average rainfall of about 1.3 inches for the period, occurred that would influence the implementation of the Plan of Control. Thus, this evaluation is made not with additional knowledge but possibly only with different objectives than the ones that were strived for by those who implemented the Plan of Control during the period in question.

a. Conformity with Control Plan 1958-D - The operation of the plan is evaluated on the degree to which it conformed with the criteria set forth in Plan 1958-D. Listed below are general groups to which one or more criteria are relevant along with the evaluation of the plan relative to the criteria.

It should be made clear prior to reading the following evaluation of the criteria that they are prefaced on supplies as received in the past (1860-1954). During the period for which they are being evaluated (January 1973 through August 1974), the rainfall in the Lake Ontario Basin was 2.1 inches above the average.

1. Water Levels at Montreal Harbour - (Criteria a, c and d.[5]) Criterion a is aimed at providing minimum depth within Montreal Harbour during the period April 1 to December 15. The latter two criteria regulate the discharge of the St. Lawrence River above Montreal and the Ottawa River during periods of high inflow from the Ottawa and spring breakup of ice in Montreal Harbour, respectively.

Criterion a was fulfilled at all times during the past two year. Criterion c and d were met through control of releases from the Moses-Saunders Dam. However, severe flooding did occur around the Montreal area due to the extreme flows discharged by the Ottawa River. This flooding was more severe in 1974 than in 1973.

2. Winter Operation - Criterion b dictates that from December 15 to March 31 the outflow be as large as feasible while minimizing the difficulties of winter operation. The operating procedures followed appear to have

---

[5]See Appendix D for wording of the criteria.

minimized the difficulties of winter operation in that no major problems were encountered during ice formation or break-up during the period in question. Nor were there any major difficulties encountered during the period of ice cover.

Due to the high water levels prevailing and anticipated, efforts were made to discharge greater flows of water during this period than normal. During the December 15-March 31 period in 1972-73, the average flow was approximately 270,000 cfs as measured at Massena, New York. In 1973-74 period it was approximately 267,000 cfs. These figures compare to an average flow for the period of about 228,000 cfs for the years 1959 to 1974.

These figures reflect a substantial effort to reduce the level of Lake Ontario during the winter months by discharging quantities of water well in excess of normal. It also reflects that the Plan of Control has a degree of flexibility in the manner in which it was implemented.

3. Flow for Power - Criterion e requires that consistent with other requirements the regulated outflow should be such as to secure the maximum dependable flow for power. It appears as if this criteria was met. As discussed earlier in this report, the percent of time that weekly outflows exceeded 270,000 cfs in 1973 was 87 percent, and in 1974 through August it was 74 percent. The average amount of time this occurred during the period 1950 through 1973 was 18 percent. This flow is accredited with production of power well above the average yearly production.

The period of time during which the flow was less than 270,000 cfs during the January, 1973 through August, 1974 period was at ice formation time (December - January). The Plan of Control, through Criterion b imposes flow restrictions at this time in order to ensure ice formation.

4. Navigation Channel - Criterion f states that maximum regulated outflow from Lake Ontario should be maintained as low as possible to reduce channel excavation to a minimum. Currently the Seaway is advertised as having a 27 foot navigational channel and maintenance of this appears to be the goal for regulation from the navigational point of view.

During the period in question this depth has been maintained except in isolated periods of extreme weather conditions. At times when high rates of discharge occurred adverse current conditions and problems associated with steerage have been experienced. However, at no time under normal weather conditions was there any limitations on the 27 foot navigational channel in the Seaway. Thus, it can be said that the operational procedures fulfilled this

criteria but as discussed earlier, several incidents incurring damage to ships or navigation facilities occurred which were attributed to low water and high currents.

5. Lake Levels - Criteria g, h, i and j set forth the constraints on Lake Ontario water levels as the result of regulation. Each of these will be examined in detail.

Criterion g states that consistent with other requirements, the levels of Lake Ontario shall be regulated for the benefit of property owners on the shores of Lake Ontario in the United States and Canada so as to reduce the extremes of stage which have been experienced.[6] As detailed in Section IV-B of this report, property owners on the shores of Lake Ontario have sustained severe damages due to the high water. In addition the lake level has established or been near the record high levels as was reflected in Figure 5. Also, during the period in question the level of Lake Ontario was above elevation 246.77, the level below which it was to be controlled, approximately 40 percent of the time.

Although the Lake exceeded the Plan of Control's established upper limit it should be noted that without the control works, it is estimated that the level would have reached 249.1 feet during 1973. This is approximately 13 inches above the actual recorded peak elevation. This reduction in elevation is the effect that man's control activities had on the level of Lake Ontario.

In light of these data it can be concluded that this criterion was not satisfied to a high degree.

Criterion h states the regulated monthly mean of Lake Ontario shall not exceed elevation 246.77 with the supplies of the past as adjusted. As stated above, Lake Ontario has exceeded elevation 246.77 approximately 40 percent of the time during the period from January, 1973 through August, 1974. Thus this criterion can be judged to have not been met with any degree of consistency.

Criterion i states that under regulation the frequency of occurance of monthly mean elevation of approximately 245.77 and higher on Lake Ontario shall be less than would have occurred in the past. For the period from January, 1973 through August, 1974, this mean monthly elevation has been exceeded approximately 68 percent of the time compared to approximately 59 percent for the period January, 1935 to December, 1954.

---

[6]Lake levels used in the International Joint Commission's Orders of Approval refer to monthly mean values.

Criterion j states that the regulated level of Lake Ontario on April 1 shall not be lower than elevation 242.77. The regulated monthly mean level of the lake from November 1 to 30 shall be maintained at or above elevation 242.77. This criterion has been fulfilled at all times over the period in question.

6. Special Conditions - Criterion k states that in the event of supplies in excess of the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to the riparian owners upstream and downstream. Since supplies were in excess of the past, this criterion should have been followed to a greater extent. This basis for this statement is that outflows have been restricted during the late summer and early fall months during both 1973 and 1974. Without these restrictions, water levels could have been reduced and upstream riparian owners could have been provided greater relief in the periods when high water normally occurs.

In summary then, it can be stated that based on the degree to which the operation of the Plan of Control conformed with the criteria set forth in Plan 1958-D it is felt that the Plan was implemented adequately with respect to navigational and power interests. Criteria relative to navigational and power interest were conformed to at all times. On the other hand, criteria relative to maximum water levels were not adequately conformed to although efforts were made through releasing outflows in excess of those called for by the Plan. Criteria relative to riparian owners were not conformed with to a satisfactory degree. It is the conditions of the times when Criterion k is utilized that makes it nearly impossible to implement this Criterion effectively due to the conflicts that exist between upstream and downstream riparian owners. Both upstream and downstream riparian owners can not be "provided all possible relief", as required by the Criterion, during times of high lake levels.

In light of the above it is felt that the implementation of the Plan, although adequate in certain areas, could have been changed and therefore possibly prevented a portion of the damages that were sustained. In addition it is felt that Criterion k is, as written, difficult to conform to.

b. Effectiveness of Plan 1958-D in Minimizing Adverse Impacts - Prior to the following discussion, two important points should be made. First, the Plan of Control 1958-D as implemented has resulted in lake levels that are

lower than would have occurred under preproject conditions.[7] These differences in lake levels are reflected in Figure 29.

This reduction in lake level undoubtedly has resulted in less damage being incurred during the recent period of high water than would have occurred without the development of the St. Lawrence River. However, quantification of the magnitude of the damage reduction was not possible.

The above has been pointed out in order to keep in mind that the current Plan of Control has afforded positive benefits to riparian owners on Lake Ontario without incurring significant damages to other interests. However, still at issue is the question whether total damages incurred by high water could be reduced through changes in the Plan of Control or its implementation.

Second, physical constraints within the Lake Ontario-St. Lawrence River drainage system limit the outflow that is possible. Prior to the development of the St. Lawrence River the record flow of the St. Lawrence was 318,000 cfs. Upon completion of the channel enlargement and other works, the record flow was increased to 351,000 cfs. achieved in 1973. Greater flow could have physically been discharged but damage would have been incurred.

The above discussion describes the benefits that are attributed to the development of the St. Lawrence River and the implementation of Plan of Control 1958-D. With this in mind an examination of the sequences of discharge passed through the control structures in an attempt to evaluate whether all interest were given consideration in the operation of the Plan of Control. This examination may seem, and it may be, subjective. However, the process of following the sequence of releases through the period in question may provide insights into the control process from which operational improvements can be recommended.

In order to evaluate the operation of the Plan for the January, 1973 through August, 1974 period, an understanding of what occurred in the fall of 1972 is required. Following is the information required for such an understanding.

Lake Ontario peaked in 1972 at elevation 246.75 on July 16, 1972.[8] This placed the Lake near the upper limit of

---

[7]Preproject conditions refer to the conditions that existed prior to construction of the St. Lawrence Seaway, the Moses-Saunders Power Facility and their associated works.

[8]246.75 is the mean daily level for July 16, 1972. The monthly mean level was 246.72 for July 1972.

the range (246.77) within which it is to be regulated. From the end of June until the middle of October the outflow was maintained at 310,000 cfs, which is the maximum outflow permitted by Plan 1958-D. By the end of October the lake level had dropped two and one quarter feet but remained approximately .5 feet above normal. At this point in time Lake Erie was still at a record high level.

As the lake level fell, difficulties experienced by navigation increased with continuation of the discharge rate of 310,000 cfs. On October 14, 1972 the outflow was reduced to the maximum specified by the plan for navigation requirements until winter limitations prevailed on December 16. Between October 13 and November 7 the lake fell .4 of a foot. From November 8 to December 15 it then rose .4 of a foot returning it to the elevation experienced on October 13, 1972.

During the calendar year 1972, precipitation in the Lake Ontario Basin exceeded the average by about 9.3 inches. Precipitation in the remainder of the Great Lakes Basin exceeded the average by about 4.4 inches. This resulted in near record or record high levels in the upper Great Lakes which in turn indicated that above average supplies of water would be forthcoming to Lake Ontario in the future.

The large discharges released in the July to mid October period raised the Montreal Harbour water level to record high levels for that period of time. The levels experienced were approximately 3 feet above the average.

In summary, the situation prevailing was one where Lake Ontario was above average in elevation and approaching the level under which it was to be regulated. Precipitation throughout the Great Lakes Basin had been well above average which signalled forthcoming supplies that would be above average. Discharges were above those called for by the Plan until navigational problems were encountered. At this time - mid October - they were reduced. With this information in mind a detailed examination of the 1973 operation procedures will be undertaken.

After the formation of an ice cover in late 1972 and early 1973 discharges were increased from the low weekly average of 230,000 cfs in the second week of January to 350,000 cfs in the first week of June. This flow was continued until the first week in August. This increase was accomplished at an almost steady rate during the period.

Inflow exceeded outflow for the majority of the period from January 1973 through May 1973 which is normal since this is the period of normal seasonal rise for Lake Ontario. From 245.45 feet on January 3 the Lake rose to 247.99 feet

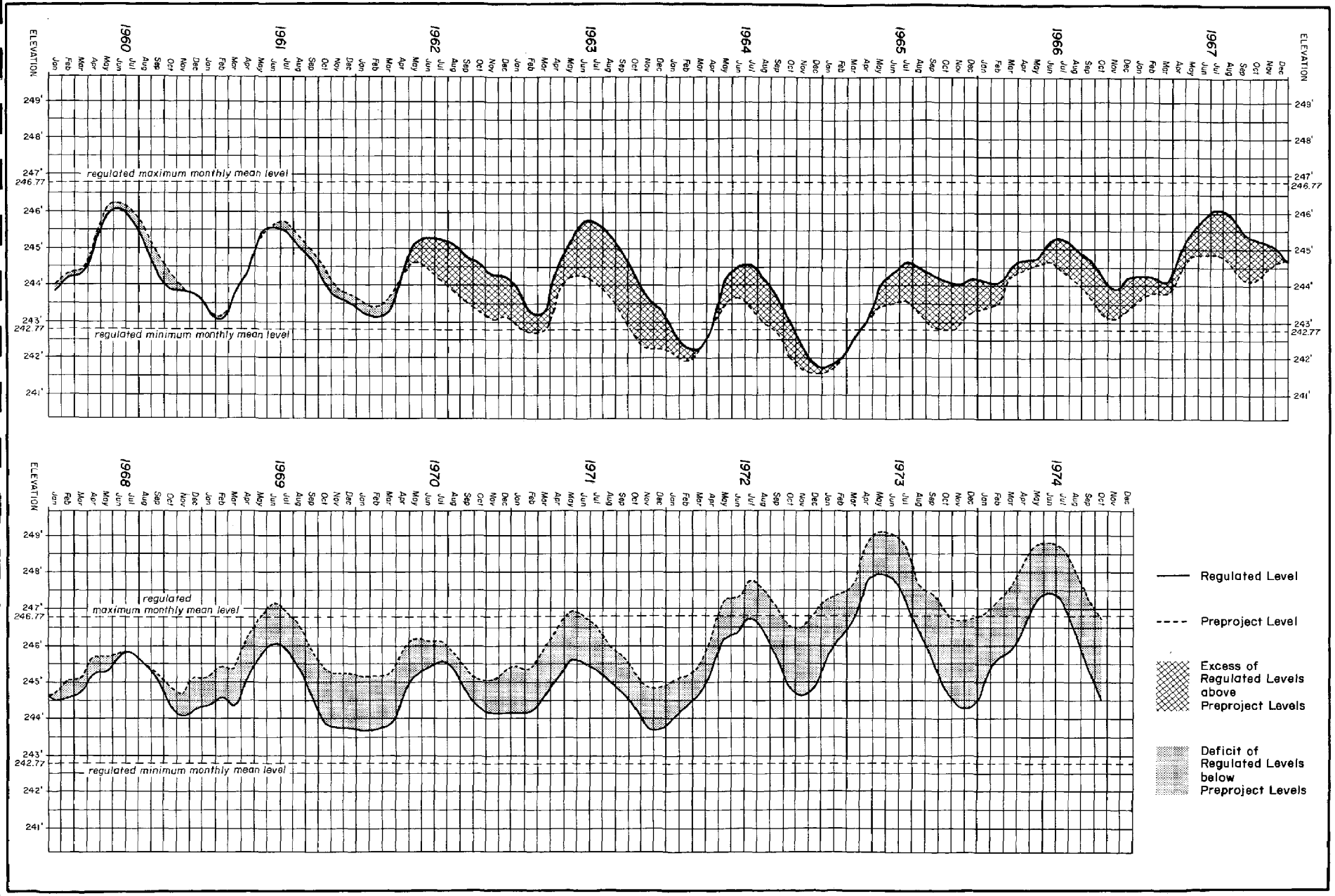


Figure 29. Lake Ontario - Comparison of Regulated With Preproject Levels 1960-1974. (Source: Data provided by U. S. Corps of Engineers, Buffalo District).

on May 31, 1973. At this point in time the Lake exceeded its average level for that time of the year by about two and one quarter feet and was above the maximum elevation (246.77) within which it is to be regulated.

During the winter of 1972-73 there was a very weak ice cover on Lake Ontario. On the weekend of March 17-18, 1973, heavy winds, in conjunction with the weak ice cover and high lake level, caused extensive damage to the shore area of the Lake in the seven counties of Jefferson, Oswego, Cayuga, Wayne, Monroe, Niagara and Orleans. Additional damage was experienced prior to and after this storm due to the lack of protection normally provided by a stable ice cover.

In June outflow began to exceed inflow and the Lake began to recede. At this point the discharge rate was maintained around 350,000 cfs until early August. Again, due to the occurrance of navigation problems, the rate of discharge was reduced steadily for the remainder of the navigation season and through the ice formation period. During this time, the lake level continued receding. It dropped from 246.85 on August 1, 1973 to 244.68 on December 31, 1973.

It should be noted that in July 1973 the record mean daily outflow from Lake Ontario was recorded.[9] This flow was 351,000 cfs measured at Cornwall, Ontario.

The effect of this large volume of discharge was felt in the area below the control structure as evidenced by the elevation of the water level at Montreal Harbour. From April into December the elevation was well above average. The record highs of 1972 for August through October were approached but not equalled.

To date in 1974 a repeat of the operations of the control structures described for 1973 has been witnessed with one minor modification. Instead of discharging at a very rapid rate and then decreasing it toward the end of the summer, a lesser discharge has occurred this year. This lesser rate will be continued for a longer period of time with the end result being approximately the same lake level being reached by late fall as was reached in the late fall of 1973.[10] Presumably, this change in operation

---

[9] 351,000 cfs was recorded on July 21, 1973 at the Cornwall Ontario gauge near Massena, NY. Data provided by USGS.

[10] The monthly mean Lake Ontario levels for October, November and December 1974 were 244.52, 244.00 and 244.03, respectively. These waters were 0.33, 0.36 and 0.33 foot, respectively, below the levels of October, November and December 1973.

will reduce some of the problems navigation encountered along with stabilizing the level of Montreal Harbour throughout the summer and early fall months.

With this brief description of the control activities in mind it is time to turn to an examination of the impact changes in these activities may have had. The examination of impacts of the high water level in Chapter IV indicates that adverse impacts were experienced by both navigation interest and riparian owners while beneficial impacts were experienced by power interest. Since this study is oriented toward minimizing adverse impacts, emphasis will be placed on examining how these adverse impacts may have been reduced.

In general terms, navigation interests desire a flow below 310,000 cfs in order to reduce velocities and to maintain a 27 foot navigation channel. Riparian owners downstream of the control structure and around Lake St. Lawrence also desire a similar discharge rate. This reduces flooding for the former and eliminates draw down of Lake St. Lawrence and the resultant "mud-flats" that occur when the flow exceeds 310,000 cfs. Riparian owners upstream of Lake St. Lawrence desire high rates of discharge during periods of above average lake levels. For those along the river this would reduce ship wake damage, and for those on the Lake it would lower the water level and the damages caused by high levels and storm surges.

As stated earlier in this report, under average water level conditions, this conflict of desired rates of discharge does not arise. However, under conditions of above normal supplies it does. As evidenced by the implementation of the Plan over the past three years, described above, it appears that the navigation interests have had the strongest hand in determining the discharge rate. This may be due to the fact that they have representation on the controlling board along with direct representation of power interest whose desires are nearly compatible during periods of above average Lake levels. Both groups have mutually agreeable goals for release rates between 270,000 and 310,000 cfs. On the other hand, riparian owners are at present not represented by a spokesman of their own. This is important because the desired release rates for riparian interest above the control structure conflicts with both power, navigation interest and riparian owners downstream during periods of high water levels.

Any attempt to determine if adverse impacts could be reduced through a different mode of operation requires substantial effort. One of the most critical elements required would be stage - damage relationships for both Lake Ontario - St. Lawrence River above the control structure and for the St. Lawrence River below the control structure

including Montreal Harbour. This is required in order to determine the effect any given change in elevation of the Lake, or River, would have in terms of change in damages.

Other necessary elements include the relationship between economic impact and various channel depths including those less than 27 feet. From this the economic impact resulting from varying channel depth could be estimated. Also the economic impact on power interests from various modes of operation should be considered.

With the four relationships described above (two stage - damage curves and an economic impact - channel depth curve and mode of operation - power impact) estimates of the impact of alternative operation methods could be derived. With these estimates trade-offs between adverse impacts to any two or more parties could be evaluated objectively. In refined form procedures could be developed by which total adverse impacts could be minimized or conversely, total beneficial impacts could be maximized.

The decisions on the mode of operation of the Plan of Control to be followed are currently made under conditions of severe institutional constraints, combined with inadequate knowledge by persons whose decisions are, at the least, biased by the fact they are employed by specific interests - riparian interests not included.[11] In addition the regulation philosophy pursued by the IJC is one that permits a change in lake level regulation plans only if no economic loss to any major interest (shore property, navigation, power) on any lake or its outflow river occurs and the existing Lake Superior and Lake Ontario regulation criteria are satisfied.

It is not possible to determine if the adverse impacts could be reduced by a different mode of operation of the Plan given the current availability of data. All that can be accomplished in this section is to raise several serious questions. Answers to these might result in changes to the current method of operating the Plan of Control.

---

[11]It should be made clear here that this statement and others throughout the text are not personal attacks on the members of the St. Lawrence River Board of Control. They are statements of the belief that persons employed full time by an agency with a specific interest "acquire" the philosophy of that agency and their institutions. This process limits the scope of problems and/or solutions, either explicitly or implicity that the individual preceives.

The first question is why, after almost 15 years of operation, has not the economic impact - channel depth relationship been determined and made available so that it can be utilized in determining the optimal mode of operation?

Secondly, why has not the International Joint Commission refined its stage - damage curves so that they can be used in determining the optimum mode of operation? This organization has been in existence long enough to realize that an acute need exists for such data.

Thirdly, since riparian owners are a major interest group influenced by the water levels of Lake Ontario and the St. Lawrence River, why are they not represented on the decision making body that determines the mode of operation of the Plan of Control?

In summary, the major question appears to be that of whether or not the institutional arrangements that exist force those who make the decision to be biased toward specific interest. This is reflected in that the Order of Approval require that a 27 foot navigational channel will be maintained at all times. Thus decisions on the mode of operation by the SLRBC are made to minimize damages given that the navigation channel is maintained; not with the objective of minimizing total damages considering all interests. At present the response to this appears to be yes, based primarily on past performance.

B. Structural Measures

Structural measures are implemented by either an individual or an agency depending primarily on the size of the project and the nature of the area to be protected. No listing of private protective structures was attempted. It is known that they are extensive in number but probably insignificant over all in reducing damages.

1. Description

The U. S. Army Corps of Engineers is the Federal agency with primary responsibility for construction and maintenance of public shore protection structures in the United States portion of the Great Lakes. Following is a brief description of the projects the Corps have constructed in the past and those that are currently authorized but not undertaken or completed.

Fort Niagara State Park - Beach Erosion Control - Fort Niagara State Park is located on the south shore of Lake Ontario at the mouth of the Niagara River. The property, formerly a U. S. Military Reservation, was acquired in 1964 by the State of New York for park development under jurisdiction of the Niagara Frontier State Park Commission. The cooperative beach erosion plan was authorized by the

Senate and House Public Works Committee in December, 1970, under provisions of the Flood Control Act of 1965. The authorized project provides for the construction of a low offshore breakwater about 4,000 feet long to protect a bathing beach that is to be improved by placement of 162,000 cubic yards of sand fill. The total estimated first cost if $3,050,000 of which the authorized federal 70 percent contribution would amount to $2,140,000. Initiation of action on this project is contingent upon reduction of pollution in the area.

Hamlin Beach State Park - Beach Erosion Control - Hamlin Beach State Park, under jurisdiction of the Genessee State Park Commission, is located on the south shore of Lake Ontario, about 20 miles west of Rochester Harbor. The cooperative beach erosion control project by the State of New York and the Federal Government authorized in July, 1958, provides for restoration and protection of the westerly beach area at the park by alteration of two existing stone and one existing concrete groin, construction of four new groins, grading of the nearly vertical bluffs behind the beach to a stable slope, and placement of approximately 217,000 cubic yards of sand fill. Authorized Federal contribution to the extent of 70 percent of the total first cost, estimated at $2,310,000, would amount to $1,618,000. Preconstruction planning was completed in 1972. As of October 1974, four of the six new groins were in place.

Table 29 reflects the current beach erosion control studies the Corps has underway. Table 30 lists authorized projects that are presently classified as inactive or deferred. This classification is generally the result of changes in conditions after project authorization and is primarily due to reduction in anticipated project benefits, lack of local cooperation, development within project area precluding project economic feasibility at this time or the proposed work which is considered not necessary at this time.

Under Public Law 84-99 as amended by Public Law 87-844, the Corps of Engineers is authorized to provide emergency assistance as required to supplement local efforts and capabilities in time of flood or coastal storm and reduce damages and human suffering. During the current period of high water on Lake Ontario the Corps, under a program called Operation Foresight, has undertaken several protective measures. These are listed in Table 31.

In addition to those areas which qualified for an Operation Foresight project from an economic point of view, there was a substantial number of areas that were found economically unfeasible. Table 32 lists these areas for minor civil divisions within Jefferson County. The Corps of Engineers informed each applicant, by letter, after

Table 29. Beach Erosion Control Surveys on Lake Ontario

NAME	PURPOSE	APPROXIMATE DATE TO BE COMPLETED
Durand-Eastman Park at Rochester	To determine the advisibility of undertaking measures for control of shore erosion along the Lake Ontario frontage of the park.	Indefinite
South Shore of Lake Ontario	To determine the advisibility of undertaking measures of control of shore erosion at several publicly owned lake frontages and related improvements for light draft craft.	
	Interim Report - Fort Niagara State Park	Favorable report submitted by District Engineer in 1968
	Interim Report - Golden Hill State Park	1971
	Interim Report - Four-mile Creek State Park	1971

Source: Water Resources Development in New York, U. S. Army Corps of Engineers, North Atlantic Division, 1973.

reconnaissance survey when an area was found to be ineligible for temporary flood control projects under the criteria of Operation Foresight.

2. Evaluation

Both the beach erosion control projects and the Operation Foresight projects have only recently been constructed. Adequate time has not elapsed upon which to base an evaluation of their effectiveness. However, an

Table 30. U.S. Army Corps of Engineers Deferred Beach Erosion Projects

Project	Locality	Year of Authorization	Federal Cost (dollars)	Year of Estimate
Fair Haven Beach State Park	Cayuga Co.	1958	546,000	1971
Selkirk Shores State Park	Oswego Co.	1954	278,000	1971

Source: Water Resources Development in New York, U.S. Army Corps of Engineers, North Atlantic Division, 1973.

appraisal of the structures has been provided by Corps of Engineers personnel.[12]

The beach erosion control facilities at Hamlin State Park appears to be effective to the extent that it is completed. Although it is too early to fully evaluate, current air photographs indicate it is performing as designed.

A field inspection by Corps of Engineers personnel of the Operation Foresight structures in August 1974 indicates that in general they have held up. Some gabions were found to be tipping due to undermining. It is possible that if a major storm occurred, sections of the gabions could be lost due to this undermining. A small amount of stone was also found to have escaped from the gabions.

In general the structures have done the job they were designed for. It is felt that they have prevented the damages as estimated and shown in Table 31. It should be reiterated that these structures were temporary in nature and were evaluated in terms of economic feasibility assuming a two year design life.

As stated earlier, man's efforts to prevent erosion from occurring on an individual lot are usually ineffective and aesthetically displeasing. Figure 30 depicts the

[12]Henry Vitale and Denton Clark of the Buffalo District, U.S. Army Corps of Engineers provided the appraisal of Operation Foresight and of beach erosion structures, respectively.

Table 31. Operation Foresight Projects - U. S. Army Corps of Engineers

Location	Area	Estimated Cost	Estimated Damages Prevented	Length of Protection (Ft.)
Chautaugua Co.	Van Buren Point	80,711	100,000	850
Niagara Co.	Olcott Harbor East	154,662	500,000	1,100
	Olcott Harbor West	56,475	100,000	500
Orleans Co.	Jones Beach	150,044	500,000	2,000
Monroe Co.				
Town of Hamlin	Brockport Water Plant Area Reach I	209,414	400,000	2,700
	Newco Beach Area (2) Reach IV Shore Acres Reach VIII	64,765	500,000	2,000
	Summer Haven Reach IX	141,219	500,000	2,000
	Woutoma Beach West Reach X			
Town of Parma	Davidson Beach West Reach XIII	*(1)	100,000	*(2)
	Davidson Beach East Reach XIV	*(1)	100,000	*(2)
	Lighthouse Beach West Reach XVI	*(1)	150,000	*(2)

Table 31. Operation Foresight Projects - U. S. Army Corps of Engineers (con't)

Location	Area	Estimated Cost	Estimated Damages Prevented	Length of Protection (Ft.)
	Bogus Point Reach XVII	*(1)	150,000	*(2)
Monroe Co.				
Town of Greece	Manitou Beach West Reach XIX	*(1)	50,000	*(2)
	Grandview Beach Reach XXIV	104,646	150,000	400
Monroe Co.				
Town of Webster	Nine Mile Point	87,255	480,000	500

(1) *All one contract $173,366
(2) *Total Length 2900'

Source: Corps of Engineers, Buffalo District.

Table 32. Projects Not Feasible Under Operation Foresight Criteria - Jefferson County, New York

Minor Civil Division	Area
Alexandria Bay	Point Vivian
	Swan Bay
	Carnege Bay
	Alexandria Sanitary Plant
	Alexandria Village Business District
Brownville	Pillar Point
Cape Vincent	Fox Creek
	Mud Creek
	Tibbets Point Road
	U. S. Coast Guard Station
Clayton	French Creek Bay
	Downtown Business Area
Ellisburg	Jefferson Park
Henderson	Henderson Harbor
	Ray Bay
	Association Island and Causeway
Hounsfield	Sackets Harbor Pumping Station
	South Shore of Sackets Harbor
	Gilmore Shore
	Boulton Beach
Lyme	Point Peninsula State Park Road Area
	Dels Marina Area
	Chaumont Bay, Bay Street Area
	Isthumas Road Area
	State Park Road, Three Mile Point Road, South Shore Road and Isthumas Road
Orleans	Fishers Landing
	Seaway Road Area
	Collins Landing
	Wellesley Island

Source: Copies of letters to each minor civil division from Corps of Engineers, Buffalo District.

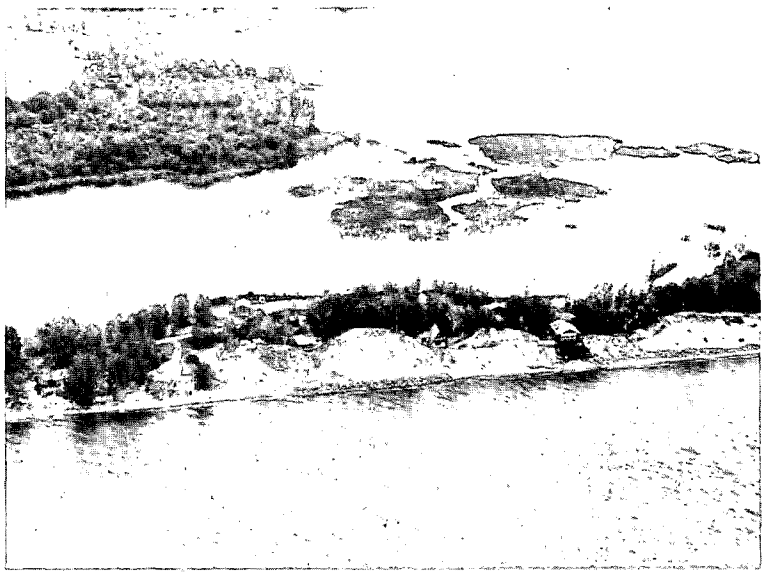


Figure 30. Man's Efforts in Action.

results of such efforts. In the upper photo the rip-rap in place may have resulted in accelerated erosion at both ends of it. In the bottom portion of the Figure the junk cars placed as a temporary wave barrier have in effect destroyed the amenities associated with a beach.

C. Flood Plain Management

1. Description

Of the numerous management techniques discussed in the preceeding chapter there are only four that have been utilized in the area under consideration. These are zoning ordinances, subdivision regulations, building codes and the federal flood insurance program. Only the last of these has damage reduction as a directly stated objective. However, the first three can be used to control or restrict man's activities in order to reduce damages due to high water.

Table 33 lists the minor civil divisions bordering Lake Ontario and the St. Lawrence River. Listed also is the current status of zoning ordinances, subdivision regulations, building codes within each of these units of government. Table 34 provides the current status of the federal flood insurance program in each of these minor civil divisions.

It should be pointed out that the mere enactment of an ordinance or regulation does not ensure that the objective of damage reduction is being fulfilled. It does provide the tools by which the goal can be achieved but this depends upon the degree of committment the governing bodies have as evidenced by enforcement. The information provided in Tables 33 and 34 only reflect the existence of programs and does not attempt to evaluate their implementation and enforcement.

2. Evaluation

An evaluation of the effectiveness of flood plain management techniques is difficult at best. This evaluation will be based primarily on whether or not management techniques have been implemented by local levels of government. An implied assumption will be that enactment of ordinances and regulations also means enforcement. This may or may not be the case.

Table 35 reflects the percentages of minor civil divisions that are utilizing various damage reduction management techniques. As can be seen, those minor civil divisions in the area serviced by the St. Lawrence-Eastern Ontario Commission have a participation rate for all four techniques examined that is well below the rate for the entire area. For zoning, subdivision regulation and

Table 33. Damage Reduction Management Techniques Implemented

Minor Civil Division	Zoning Ordinance			Subdivision Regulation			Building Code		
	In Effect	In Process	None	In Effect	In Process	None	In Effect	In Process	None
Cayuga County									
V. Fair Haven		X				X	9/68		
T. Sterling		X		5/68					X
Jefferson County									
T. Alexandria			X			X			X
V. Alexandria Bay	9/72					X			X
T. Brownville			X			X			X
V. Brownville			X			X			X
T. Cape Vincent			X			X			X
V. Cape Vincent		X				X			X
V. Chaumont			X			X			X
T. Clayton			X			X			X
V. Clayton	10/73					X			X
V. Dexter			X			X			X
T. Ellisburg	7/71			X			X		
V. Ellisburg	10/71			X					X
V. Glen Park			X			X			X
T. Henderson		X		X				X	
T. Hounsfield			X			X			X
T. Lyme			X			X			X
V. Mannsville	10/72								X
T. Orleans	4/73				X		4/73		
V. Sackets Harbor	1971			3/60	X		8/62		
Oswego County									
V. Lacona			X			X			X
T. Mexico			X			X			X
V. Mexico	5/57					X	6/74		
T. New Haven			X			X			X
C. Oswego	7/73					X	X		
T. Oswego	2/74			X					X
V. Pulaski	5/74			10/57			8/58		
T. Richland	7/73					X			X
T. Sandy Creek			X			X			X
V. Sandy Creek			X			X			X
T. Scriba		(Proposed)	X			X			

Table 33. Damage Reduction Management Techniques Implemented

Minor Civil Division	Zoning Ordinance			Subdivision Regulation			Building Code		
	In Effect	In Process	None	In Effect	In Process	None	In Effect	In Process	None
St. Lawrence County									
T. Hammond			X			X			X
V. Hammond			X			X			X
V. Heuvelton			X			X			X
T. Lisbon			X			X			X
T. Louisville	11/70			11/70			11/70		
T. Massena			X			X			X
V. Massena	1971			11/53			8/54		
T. Morristown			X			X			X
V. Morristown			X			X			X
C. Ogdensburg	X								
T. Oswegatchie			X			X			X
T. Waddington			X			X			X
V. Waddington	7/54			X			X		
Monroe County									
T. Greece	1961			X			X		
T. Hamlin	X			X			X		
T. IronDequoit	1964			X			X		
T. Parma	1963			X			X		
C. Rochester	X			X			X		
T. Webster	1969			X			X		
Niagara County									
T. Newfane			X			X			X
T. Porter			X			X			X
T. Somerset			X			X			X
T. Wilson			X			X			X
V. Wilson			X			X			X
V. Youngstown			X			X			X
Orleans County									
T. Carlton	1956					X			X
T. Kendall	1966					X	X		
T. Yates	X					X			X

Table 33. Damage Reducation Management Techniques Implemented

Minor Civil Division	Zoning Ordinance			Subdivision Regulation			Building Code		
	In Effect	In Process	None	In Effect	In Process	None	In Effect	In Process	None
Wayne County									
T. Huron	1973					X	X		
T. Ontario	X			X			X		
T. Sodus	1969			X			X		
V. Sodus Pt.	X			X			X		
T. Williamson	1972			X			X		
T. Wolcott		X				X			X

Source: Data gathered by the St. Lawrence-Eastern Ontario Commission personnel and verified by Erie-Niagara Regional Planning Board, Genesee/ Finger Lakes Regional Planning Board and Oswego County Planning Board.

building codes, it is less than half the rate of that for minor civil division in the rest of the area. For flood insurance program participation it is only 16 percent, compared to 95 percent for the rest of the area.

Low participation rates, combined with the fact that the majority of the ordinances and regulations in effect were passed since 1970 and the fact that eligibility for the flood insurance program for most of the minor civil divisions has been established since 1972, indicates that little effort has been expended by local government to prevent or reduce damages until very recently. The results of this are that development has occurred in areas where it is not compatible with the environmental limitations. This has resulted in great amounts of damage from high water levels.

The effort to implement damage reduction management techniques now underway by local governmental units will aid in preventing future damages due to limitation of development in hazardous areas. These efforts will have little or no effect on reducing the damages that will be sustained by the current development. Participation in the flood insurance program will aid in shifting the burden of damages to the property owner when, and if, the insurance rates eventually are tied to the risk involved and the government discontinues subsidizing the program.

Table 34. Federal Flood Insurance Program Participation

Minor Civil Division	No Contact	Tentively Identified	STATUS Notified	Maps Published	Eligible
Cayuga County					
V. Fair Haven				2/22/74	4/20/73
T. Sterling		X	7/26/74	7/26/74	
Jefferson County					
T. Alexandria			5/31/74	5/31/74	
V. Alexandria Bay				2/22/74	6/21/73
T. Brownville		X			
V. Brownville			5/10/74	5/10/74	
T. Cape Vincent		X			
V. Cape Vincent			5/24/74	5/24/74	
V. Chaumont			5/17/74	5/17/74	
T. Clayton			6/14/74	6/14/74	
V. Clayton				5/31/74	3/8/74
V. Dexter			7/26/74	7/26/74	
T. Ellisburg				4/5/74	5/29/73
V. Ellisburg			8/30/74	8/30/74	
V. Glen Park			3/29/74	3/29/74	
T. Henderson				8/9/74	
T. Hounsfield				8/2/74	
T. Lyme		X			
V. Mannsville		X			
T. Orleans				5/31/74	6/6/73
V. Sackets Harbor			5/31/74	5/31/74	
Oswego County					
V. Lacona			11/22/74	11/22/74	
T. Mexico		X	11/17/74	11/17/74	
V. Mexico		X			
T. New Haven		X	7/19/74	7/19/74	
C. Oswego				5/10/74	4/30/73
T. Oswego			5/31/74	5/31/74	
V. Pulaski			5/10/74	5/10/74	
T. Richland				7/26/74	3/21/74
T. Sandy Creek			5/24/74	5/24/74	
V. Sandy Creek			11/15/74	11/15/74	
T. Scriba		X	7/19/74	7/19/74	
St. Lawrence County					
T. Hammond		X			
V. Hammond	X				
V. Heuvelton			5/24/74	5/24/74	

Table 34. Federal Flood Insurance Program Participation (con't)

Minor Civil Division	No Contact	STATUS Tentively Identified	Notified	Maps Published	Eligible
St. Lawrence County					
T. Lisbon			8/16/74	8/16/74	
T. Louisville		X			
T. Massena		X			
V. Massena			3/8/74	3/8/74	
T. Morristown			9/6/74	9/6/74	
V. Morristown			5/31/74	5/31/74	
C. Ogdensburg			7/26/74	7/26/74	
T. Oswegatchie			9/13/74	9/13/74	
T. Waddington		X			
V. Waddington		X			
Monroe County					
T. Greece				1/18/74	3/9/73
T. Hamlin				1/18/74	3/2/73
T. IronDequoit				6/28/74	3/16/73
T. Parma				11/9/73	3/9/73
C. Rochester				6/28/74	4/9/73
T. Webster				6/28/74	3/9/73
Niagara County					
T. Newfane				5/17/74	4/10/73
T. Porter				4/12/74	7/17/74
T. Somerset				3/15/74	5/24/73
T. Wilson				5/17/74	5/21/73
V. Wilson				4/5/74	2/15/74
V. Youngstown				3/1/74	3/30/74
Orleans County					
T. Carlton				8/2/74	4/5/73
T. Kendall				4/12/74	3/30/73
T. Yates				6/28/74	6/12/73
Wayne County					
T. Huron					7/23/74
T. Ontario				5/31/74	5/15/73
T. Sodus				8/16/74	3/30/73
V. Sodus Pt.				8/31/73	3/9/73
T. Williamson				6/28/74	3/23/73
T. Wolcott			6/28/74	6/28/74	

Source: Data gathered by the St. Lawrence-Eastern Ontario Commission personnel and verified by Erie-Niagara Regional Planning Board, Genesee/ Finger Lakes Regional Planning Board and Oswego County Planning Board.

Table 35. Utilization of Damage Reduction Management Techniques[a]

Technique	% Participation in SLEOC[b]	% Participation Rest of Area[c]	% Participation Total
Zoning			
In Effect	36	67	45
In Process	11	0	8
None	53	33	47
Subdivision Regulation			
In Effect	22	47	30
In Process	7	0	5
None	71	53	65
Building Codes			
In Effect	25	58	35
In Process	2	0	2
None	73	42	63
Flood Ins. Program			
Eligible	16	95	41

[a]As of September 1, 1974. Oswego County as of January 8, 1975.

[b]The St. Lawrence-Eastern Ontario Commission includes those towns in Cayuga, Jefferson, St. Lawrence and Oswego Counties bordering Lake Ontario or the St. Lawrence River.

[c]The "rest" includes those towns in Wayne, Monroe, Niagara and Orleans Counties bordering Lake Ontario.

Source: Adapted from tables 33 and 34.

It appears that local efforts to reduce damages have been limited when measured by the participation rates in damage reduction management techniques. It is encouraging to see efforts have been taken since 1970 and that the federal flood insurance program, combined with New York State flood plain management legislation (see Appendix C), will ensure that additional efforts will be forthcoming quickly.

Again the point should be made that enactment does not ensure enforcement. Thus, one must not be misled by participation rates. A true indication of the efforts made

must await the test of high water levels. The current test indicates that insufficient effort has been put forth as evidenced by the vast amounts of damage done to structures near or on the flood plains of Lake Ontario and the St. Lawrence River.

SELECTED REFERENCES

1. Climatological Station Data Catalogue - Ontario Dept. of Transport, Meteorological Branch 1970.

2. Coastal Construction Setback Line, James Purpura and William Sensabaugh, Florida Cooperative Extension Service, Marine Advisory Program, 1974.

3. Convention Concerning the Boundary Water Between The United States and Canada, Treaties, Conventions, International Acts, Protocals and Agreements, 1910-1923 Volume III, Government Printing Office, Washington, D. C., 1923.

4. Flood Plain Information, Ontonagon County, Michigan, Dept. of the Army, St. Paul District, Corps of Engineers, 1970.

5. Forecasting The Levels of the Great Lakes, U. S. Lake Survey Misc. Paper 67-2, B. G. DeCooke and E. Megerian, Sept., 1967.

6. Great Lakes and Connecting Channels Water Levels and Depths, Department of the Army, Corps of Engineers, (monthly).

7. Great Lakes Basin Framework Study, Main Report and Appendicies 1-24, Great Lakes Basin Commission (drafts of this report are of various dates).

8. Great Lakes Region Inventory Report National Shoreline Study, Dept. of the Army, Corps of Engineers, North Central Division, Army, 1971.

9. Great Lakes Shore Erosion in Michigan - Status Report, State of Michigan, Dept. of Natural Resources, Water Resources Commission, 1969.

10. Great Lakes Shoreland Damage Reduction Program, Report Number 1, Great Lakes Basin Commission Shore Use and Erosion Work Group, Nov., 1973 (Draft)

11. Great Lakes Shoreline Damage Causes and Protective Measures, U. S. Army Corps of Engineers, North Central Division, May, 1972.

12. Lake Ontario Data, Department of the Army, Corps of Engineers, (weekly).

13. Low Cost Shore Protection for the Great Lakes, Research Publication No. 3, University of Michigan Lake Hydraulics Laboratory in Cooperation with Michigan Water Resources Commission, reprinted 1959.

14. Monthly and Yearly Mean Water Levels 1972, Department of the Environment, Ottawa, Canada, Vol. 1, Inland 1973.

15. Monthly Water Level Bulletin - Great Lakes and Montreal Harbour, Department of Environment, Ottawa, Canada (monthly).

16. New York State Supplemental Budget, 1973-74, New York State.

17. Order of Approval, October 29, 1952 as amended by Order of Approval, July 2, 1956, International Joint Commission, (official consolidation).

18. Ottawa River Basin - Water Quality and Its Control in the Ottawa River, Volume 1, Prepared by Ontario Water Resources Commission and Quebec Water Board, 1971.

19. Power Authority of the State of New York - Annual Report, Power Authority of the State of New York, 1972, 1973.

20. Regulation of Great Lakes Water Levels, International Great Lakes Levels Board, Report to the IJC, Main Report, Summary and Appendix A-G, December 7, 1973.

21. Regulation of Lake Ontario, Operational Guides For Plan 1958-D, Report to the IJC, The International St. Lawrence River Board of Control, December 12, 1963.

22. Regulation of Lake Ontario Plan 1958-D, Report to the IJC, The International St. Lawrence River Board of Control, July, 1963.

23. Regulation of Lake Ontario, Plan 1958-D, Report to the IJC, The International St. Lawrence River Board of Control, Vol. 2, Appendix A, May 14, 1958.

24. Regulation of Lakes Superior and Ontario Plan SO-901, Draft Environmental Statement, U. S. Army Engineer District Detroit, Corps of Engineers, Detroit, Mich., Sept., 1974.

25. The Regulation of Water Levels on the Great Lakes: Emphasis on Lake Ontario, Frank Sciremammano, (Department of Mech. and Aerospace Science, Univ. of Rochester, Rochester, N.Y.) (July 7, 1973) (Preliminary Report - Draft).

26. Report on Hydrology and Regulation of the Ottawa River, Appendix 1, Hydrologic and Forecasting Studies, Ottawa River Engineering Board, June, 1965.

27. Report on Hydrology and Regulation of the Ottawa River, Appendix 2, Flow Regulation Studies, June, 1965.

28. 1974 Report of Member Electric Corporation of the New York Power Pool and the Empire State Electric Energy Research Corporation pursuant to Article VIII, Section 149-B of the Public Service Law; Volume 1.

29. Report on the National Shoreline Study, Dept. of the Army, Aug., 1971.

30. St. Lawrence-Eastern Ontario Shoreline Study, Prepared for SLEOC by SUNY, College of Environmental Science and Forestry, April 28, 1972, Summary and Technical Reports 1-11.

31. Saint Lawrence Power Project Data & Statistics, Power Authority of the State of New York (NDG).

32. Saint Lawrence Seaway Development Corporation, Annual Reports - 1968, 1969, 1970, 1972, 1973, U. S. Dept. of Transportation.

33. Seaway Notice Affecting Navigation, Saint Lawrence Seaway Development Corporation, 1973, 1974.

34. Shore Erosion on the Great Lakes - Saint Lawrence System, Part 1 - Summary Report, Part 2 - Shore Erosion on the Great Lakes System and Part 3 - Shore Erosion on the St. Lawrence System Below Cornwall, Government of Canada, 1973.

35. Shore Erosion in Ohio, State of Ohio, Department of Natural Resources, Division of Shore Erosion, 1959.

36. Shore Management Guidelines, Dept. of the Army, Corps of Engineers, Washington, D. C., August, 1971.

37. Shore Protection Guidelines, Dept. of the Army, Corps of Engineers, Washington, D. C., August, 1971.

38. Shore Protection Planning and Design, Technical Report No. 4, Coastal Engineering Research Center, Corps of Engineers.

39. Shoreland and Flood Plain Zoning Along Wisconsin Shores of Lakes Michigan, A. R. Striegl, State of Wisconsin, Dept. of Natural Resources, Division of Resource Development.

40. Shoreline Erosion Study, Lake Erie Shoreline, Lake County, Ohio, State of Ohio, Dept. of Natural Resources, August, 1969.

41. Water Levels 1972, Department of the Environment, Canada, Volume 1, Inland, 1973.

42. Water Levels on Lake Ontario: A Fact Sheet, U. S. Army Corps of Engineers, Buffalo District, June, 1974.

43. Water Quality and Its Control in the Ottawa River, Volume 1, Ontario Water Resources Commission and the Quebec Water Board, 1971.

44. Water Resources Development in New York, U. S. Army Corps of Engineers, North Atlantic Division, 1973.

45. What Actually Happened This Past Spring, Final Narrative Report, Lawrence Leopold, Sea Grant Advisory Service, Brockport, N. Y., August, 1973.

46. Help Yourself, Dept. of the Army, Corps of Engineers, North Central Division.

APPENDIX A

RELATED STUDIES AND REPORTS

Appendix A

Related Studies and Reports

Summarized below are several studies of significance that have been completed recently and which bear directly on the topics discussed in this report. Included also are descriptions of studies known to be currently underway.

A. Studies and Reports Recently Completed -

1. A Strategy for Great Lakes Shoreline Damage Reduction, The Joint Federal Regional Council - Great Lakes Basin Commission Task Force for Great Lakes Shorelands Damage Reduction, March, 1974.

This report was prepared to serve as a focal point for consideration of the development and implementation of a strategy for Great Lakes shoreland damage reduction by the Governors of the Great Lakes States. Emphasis is directed at identifying an early and sustained action strategy which can be supported by all levels of government. The strategy emphasizes proper land use planning on the one hand and the need to stabilize certain reaches on the shoreland on the other.

Seven alternatives for action were determined to be available to reduce erosion and flooding, structural damage, and resulting losses and hardships. These alternatives were evaluated against the following set of selection criteria:

a) Shoreland integrity and uniqueness should be protected and preserved by minimizing the impact of development;

b) Future losses should be controlled primarily by nonstructural means;

c) Extensive government financed structural control measures cannot be justified economically especially for the short term. Protection of essential public facilities and public lands is important now;

d) Major structural control is needed to protect shoreland resources, to reduce economic losses to private development and to enhance Great Lakes water quality;

e) Extensive public funding support is not available for protection of privately owned property;

2. Great Lakes Shoreland Damage Reduction Program, Great Lakes Basin Commission Shore Use and Erosion Work Group, November, 1973.

This brochure summarizes the status and scope of Federal programs for minigating shore damages on the Great Lakes and the interest of the Great Lakes State in the strategy alternatives for shoreland damage reduction.

The following seven elements of the strategy are discussed:

a) Further lake regulation to reduce high levels.

b) Structural protection against erosion and flooding, both permanent and temporary, including methods of reducing ground water effects on bluffs.

c) Regulatory action to modify or avoid any construction in navigable water which tends to aggravate erosion and flooding.

d) Remedial measures to modify improperly designed navigational works and repair accumulated damages.

e) Zoning and structural setback requirements to prevent further development on vulnerable shorelands.

f) Acquisition and relocation of development from vulnerable shorelands.

g) Insurance against or reimbursement from other sources for damage from erosion and flooding.

3. Great Lakes Shoreline Damage, Causes and Protective Measures, U. S. Army Corps of Engineers, May, 1972.

This report is organized in three parts. Part I provides a history of lake levels, causes of fluctuations and, most important, effects of lake level changes on shorelines. Part II discusses the role of Federal and State Governments in various activities and responsibilities on the Great Lakes related to water and shore areas. It includes information on available data and the sources of such data. Part III provides a brief discussion of several emergency type remedial measures, estimates of their cost and general statements on their applicability to various typical situations.

4. The following four reports resulted from the National Shoreline Study authorized in 1968 by Congress to appraise shore erosion and shore protection needs in the United States.

a) Great Lakes Region Inventory Report, Department of the Army, Corps of Engineers, North Central Division, August, 1971.

This is one of nine regional reports. It assesses the nature and extent of erosion; develops conceptual plans for needed shore protection; develops general order-of-magnitude estimates of cost for the selected shore protection and identifies shore property owners within the Great Lakes Drainage Basin.

b) Shore Protection Guidelines, Department of the Army, Corps of Engineers, Washington, D. C., August, 1971.

This report describes typical erosion control measures and presents examples of shore protection facilities and criteria for planning shore protection programs.

c) Shore Management Guidelines, Department of the Army, Corps of Engineers, Washington, D. C., August, 1971.

Provided in this report is information to assist decision makers in developing and implementing shore management programs. Examples of successful management programs at both the state and local levels are given.

d) Report on the National Shoreline Study, Department of the Army, August, 1971.

This document is addressed to the Congress and summarizes the findings of the study and recommends priorities among problem areas for action to stop erosion.

5. Regulation of Great Lakes Water Levels, Report to the International Joint Commission by the International Great Lakes Levels Board, December, 1973.

The purposes of this study were:

a) to review the various factors affecting the fluctuations of the water levels of the Great Lakes.

b) to determine the feasibility of regulating further the water levels in the Great Lakes and connecting channels so as to bring about a more beneficial range of stage and other improvements.

c) to determine the changes in existing works or other measures within the basin needed to acomplish such regulation that would be practicable and in the public interest.

d) to provide an estimate of the costs of such measures, and

e) to indicate the probable effects, beneficial or adverse, in each country of any regulation plans or measures proposed.

In summary form the conclusions were: a) small net benefits to the Great Lakes system would be achieved by a new regulation plan for Lake Superior which takes into consideration the levels of both Lake Superior and Lakes Michigan - Huron; b) regulation of Lakes Michigan - Huron by the construction of works in the St. Clair and Detroit Rivers does not warrant any further consideration; c) further study is needed of the alternatives for regulating Lake Erie and improving the regulation of Lake Ontario, taking into account the full range of supplies received to date; d) the hydrologic monitoring network of the Great Lakes Basin should be progressively improved; and e) appropriate authorities should act to institute land use zoning and structural setback requirements to reduce future shoreline damage.

6. St. Lawrence-Eastern Ontario Shoreline Study, prepared for the St. Lawrence-Eastern Ontario Commission by the State University of New York, College of Environmental Science and Forestry, April 28, 1972.

Detailed data and information for the St. Lawrence-Eastern Ontario area as it applies to physiography, geology and soils, waters, natural vegetation, wildlife, fisheries, and recreation are presented in seven technical reports with maps and a summary report. Using the resource data gathered, developmental suitability was also investigated with special reference to environmental impact. The report points out the value of the natural resources to the area and, furthermore, provides a productivity rating for fisheries and wildlife habitat and natural vegetation.

7. Great Lakes Framework Study, Great Lakes Basin Commission, (partially completed).

The Framework Study is the first step toward preparation of a comprehensive, coordinated joint plan for the development and utilization of the water and related resources in the Great Lakes Basin. Included in this report are the analysis and findings of the federal, state and local agencies involved in water and related resource planning and development within the Great Lakes Basin.

8. Report to Assembly Scientific Staff, Frank Scieremammano, Jr., February 26, 1973.

The purpose of this report was to explain the operating procedures used in regulating Lake Ontario water levels. The outflows for the year and the procedures by which they were arrived at were reviewed. Criticism of certain aspects of the operating plan and the 1973 operational procedures were stated. It was also shown how alternative actions might have relieved some of the flooding that occurred on the Lake in 1973.

9. Shore Erosion On the Great Lakes - St. Lawrence System, Parts 1, 2 and 3, Government of Canada, 1973.

This report was published in three parts. Part 1, the Summary Report, contains a general description of shore erosion in the Great Lakes - St. Lawrence System and discusses its causes, its nature and location, and its social and economic implications. Part II of the report, Shore Erosion in the Great Lakes System, provides a more detailed description of shore erosion in the Canadian portion of the Great Lakes and St. Lawrence River above Cornwall. Part III of the report, Shore Erosion on the St. Lawrence System below Cornwall, describes in detail shore erosion on the St. Lawrence River and Estuary and the Quebec shoreline of the Gulf of St. Lawrence.

10. Major Findings and Recommendations of the Tentative Board Plan - St. Lawrence Basin, St. Lawrence - Franklin Regional Water Resources Planning Board and New York State Department of Environmental Conservation, June, 1974.

Set forth in this report are the findings and recommendations of the St. Lawrence - Franklin Regional Water Resources Planning Board. Recommendation 2 states that "the International Joint Commission should undertake a lake level regulation study of the Lake Ontario - St. Lawrence River Subsystem of the Great Lakes with New York State representation and with objectives of (1) developing improved methods of regulating the subsystem and (2) developing data on high and low water level conditions for use in management of shore-line areas which would be valuable information for the State's Coastal Zone Management Program."

B. Studies and Reports Underway

1. Lake Ontario Water Level Prediction, The University of Rochester, Rochester, New York, Frank Sciremammano, Jr.

An attempt to develop a method of forecasting water levels 12-18 months in advance will be undertaken. This method will take advantage of the long lag time (as much as

three years) between the onslaught of heavy rains in the Great Lakes Basin and the consequent change in Lake Ontario water levels.

The water level time series will be split into two components. One is the long time-scale fluctuations associated with basin-wide precipitation excess and the other short term and seasonal components. A deterministic linear model will be fit to the long term component with rainfall as the imput. A weighted, lagged combination of each lake's rainfall will be used as the rainfall imput. The shorter scale fluctuations will be treated as a stochastic time series and an attempt will be made to find a generating process for it. This will yield a long-term forecast and the statistical bounds within which it is likely to fall.

2. Engineering Studies For a Contract For Field Investigation of High Water Damages In (Selective) County, Detroit District, Corps of Engineers.

In this study about 14 counties in the Great Lakes Basin will be examined in detail for the purpose of determining economic damages and environmental and social losses resulting from or associated with the high levels of the Great Lakes for the period July 1972 to July 1974. The work shall conform to the general guidelines and detailed procedures specified herein for collecting, analyzing and displaying data. These data are needed to evaluate the positive and negative effects of a large number of Federal and state programs directed at reducing or mitigating Great Lakes shore damages.

The activities required as part of the Contract include development and management of a self-administered shoreland damage assessment program, follow-up field interviews, on-site inspections and field surveys, office computations and analysis, and report preparation. The work shall include the following tasks:

a. Compile a list and prepare maps of the complete riparian shoreline ownership, use and description in the counties under study. This will involve a complete review of existing County land records.

b. Design, print and distribute a self-administered Great Lakes shoreland damage questionnaire to all known riparian residential shoreland owners and analyze and compile the results of the returned questionnaire.

c. Conduct a follow-up personal interview of a random sample of residential property owners to further support and evaluate the information provided by the questionnaire.

d. Conduct a field damage survey of commercial, industrial, public buildings, transportation facilities, and public and private utilities and compile the results.

e. Compile a list of existing erosion control and flood protection structures and provide general evaluations of their effectiveness including damage reduction benefits, costs, and condition relationships.

f. Conduct field studies and review topographic maps to establish high-water marks, areas flooded and depth of flooding relationships. Tabulate high-water marks and identify flood-prone areas on maps.

g. Conduct damage surveys of flood plain areas by interviewing flood victims. Determine existing flood damages, damages for a range of stages and damages prevented by emergency construction. Compile data on damage appraisal forms and summarize the information on tables.

h. Collect information on shore damages including newspaper accounts of storm damages and available photographs of damage areas. Present this information in appendices to the report.

i. Analyze the short term high-water recession of the Great Lakes shorelands. Compute the volumetric contribution of bluff erosion sedimentation to the Great Lakes. Provide bluff and surf zone profiles. Present information on maps and charts.

j. Compile available information on the effects of high-water on recreational opportunities and aesthetic and environmental values.

k. Prepare maps, charts and graphs to illustrate the results of the damage survey.

l. Prepare a draft and final report and appendices in the format specified in this contract. The final report will be camera ready for printing.

3. The Canada/Ontario Great Lakes Shore Damage Survey Report, Environment, Canada.

This report will evaluate shoreline damage due to high water levels and storms during the period November, 1972 to November, 1973 and will recommend subsequent strategies in shoreline management, planning and shore protection. Completion Date: November, 1974.

APPENDIX B

LIST OF REFERENCES - SHORE PROTECTION MEASURES

Appendix B

List of References - Shore Protection Measures

Title	Publishing Agency
Shore Protection Planning and Design Technical Report No. 4	Coastal Engineering Research Center, Corps of Engineers
Shore Erosion in Ohio	State of Ohio, Department of Natural Resources, Division of Shore Erosion, February, 1959
Low Cost Shore Protection for the Great Lakes, Research Publication No. 3	University of Michigan Lake Hydraulics Laboratory in co-operation with Michigan Water Resources Commission, reprinted October, 1959
Shoreland and Flood Plain Zoning Along Wisconsin Shore of Lake Michigan	A. R. Striegl, State of Wisconsin, Department of Natural Resources, Division of Resource Development
Great Lakes Shore Erosion in Michigan-Status Report	State of Michigan, Department of Natural Resources, Water Resources Commission, June, 1969
Shoreline Erosion Study Lake Erie Shoreline, Lake County, Ohio	State of Ohio, Department of Natural Resources, August, 1969
Flood Plain Information Ontonagon River, Ontonagon, Michigan and Lake Superior Shoreline, Ontonagon County, Michigan	Department of the Army, St. Paul District, Corps of Engineers, September, 1970
Great Lakes Shoreland Damage - Causes and Protective Measures	U.S. Army Corps of Engineers, North Central Division, May 1972

Title	Publishing Agency
Shore Management Guidelines	Dept. of the Army, Corps of Engineers, Washington, D. C. August 1971
Shore Protection Guidelines	Dept. of the Army, Corps of Engineers, Washington, D. C. August 1971
Help Yourself	Dept. of the Army, Corps of Engineers, North Central Division

APPENDIX C

FLOOD INSURANCE PROGRAM SUMMARY

Appendix C

National Flood Insurance Program

I. Background

The National Flood Insurance Program was first established through passage of Federal Legislation entitled the National Flood Insurance Act of 1968. The most recent expansion of this program is incorporated in the Flood Disaster Protection Act of 1973, which was signed into law by the President on December 31, 1973.

II. Program Purpose

The stated purpose of this program is to provide better protection to the public and to reduce annual disaster assistance outlays through the increased availability of flood insurance.

III. The Program Objectives Are:

A. to implement land use controls (in flood-erosion hazard zones) designed to prevent those types of land use and/or construction that are prone to damage due to flooding, the erosive action of streams and lakes, mud slides, etc.

B. to make federally subsidized flood damage insurance available to persons owning property within identified flood hazard zones within communities or municipalities that adopt and enforce adequate flood hazard zone land use controls.

IV. Main Provisions

A. Requirements for Program Qualification - Local Government. A unit of local government may become qualified for participation in the Federal Flood Insurance Program by:

1. providing satisfactory proof that they currently enforce flood hazard zone land use controls satisfactory to The Department of Housing and Urban Development (HUD) requirements; or

2. if such controls are not in effect, by:

a. cooperating with HUD in the identification and mapping of flood hazard zones within the municipality;

b. enacting a building permit review system requiring a permit for construction on all lands within the municipality - including those in identified flood hazard zones;

c. local governing officials meeting in session pass resolutions to the effect: 1) that the government unit recognizes the existence of a flooding problem within its municipal boundaries and expresses its desire to comply with future improvement measures, and 2) that instructions are established and directed to an enforcement officer who is charged with the review of permits for construction within flood hazard areas;

d. making a formal application to HUD for inclusion in the Federal Flood Insurance Program;

e. complying with any resulting further specifications by HUD for qualification; or,

3. if the municipality fails to seek inclusion in the Federal Flood Insurance Program (in New York State) and is found by HUD to have flood hazard zone(s) within its political boundaries:

a. if a municipality fails to seek inclusion in the program by mid-1975, the New York State Department of Environmental Conservation (by legislative authority) shall prescribe appropriate land use controls for that municipality thus qualifying the residents of that municipality for participation in the Federal Flood Insurance Program (subsidized flood damage insurance).

B. Requirements for Eligibility - Property Owners

Property owners may become eligible for purchase of subsidized flood damage insurance when the municipality their property is located in has been qualified by HUD for participation in the Federal Flood Insurance Program.

C. Sanctions

Sanctions will be imposed upon municipalities with identified flood hazard zones that fail to qualify for inclusion in the Federal Flood Insurance Program. The primary sanction prohibits lending institutions controlled by Federal regulations to lend money for construction or renovation within the hazard area of municipalities that have not qualified for the program. In addition, flood insurance, if available, must be purchased in connection with Federally related financing of projects in identified flood-prone areas as a condition for Federal assistance in times of disasters.

D. Subsidized Flood Damage Insurance Coverage Available

Following are listed the maximum amounts of subsidized insurance available, by type of structure, under the current insurance program:

Type Structure	Structure Maximum Coverage	Structure Cost/ $100	Contents Maximum Coverage	Contents Cost/ $100
Single Family Residence	$ 35,000	$.25	$ 10,000	$.35
Apartment House	$100,000	$.40	$ 10,000	$.40
Non-Residential Structure	$100,000	$.40	$100,000	$.75

V. Participating Agencies

Federal: Department of Housing and Urban Development
Federal Insurance Administration
Washington, D. C. 20010

New York State: The NYS Dept. of Environmental Conservation
Office of Program Development,
Planning and Research Programming and Analysis Bureau
50 Wolf Road
Albany, New York 12201

VI. References

A. Enabling Legislation

1. Federal

National Flood Insurance Act of 1968 as Amended (enacted by Housing and Urban Development Act of 1968) Public Law 90-448, approved August 1, 1968.

Housing and Urban Development Act of 1969 Public Law 91-152, approved December 24, 1969.

Flood Disaster Protection Act of 1973 Public Law 93-234, approved December 31, 1973.

2. New York State

Chapter 839

(Laws of 1974 - Article 36 of the Environmental Conservation Law)

B. Key Publications Related to the National Flood Insurance Program, Flood Damage, Flood Plain Management, and Land Use Controls Related to Flood Hazard Reduction

1. "A Guide to Planning and Zoning Laws of New York State," revised, December, 1973, State of New York, Office of Planning Services, available New York State Office of Planning Services, Albany, New York, or National Technical Information Center, 5285 Port Royal Road, Springfield, VA, 22151, 115 pp.

2. "Community Response to Flood Risks," and "Federal Flood Insurance," Compiler, Lyle S. Raymond, Jr., Extension Associate, Water Resources, Cooperative Extension, New York State, Cornell University, State University of New York, Ithaca, New York, October, 1972, 35 pp., illus.

3. "Flood Plain Management -- A challenge for the State," Water Resources Commission, Division of Water Resources, New York State Conservation Department, July, 1967, 104 pp., illus.

4. "Flood Plain Management and the National Flood Insurance Program," NYS Dept. of Environmental Conservation, Albany, New York, 12201, 17 pp., illus.

5. "Flood Plain Information," prepared for Broome County (New York) Legislature by Baltimore District, Corps of Engineers, December, 1969 (Susquehanna and Chenango Rivers), 57 pp., illus.

6. "Model Zoning Ordinances for Flood Hazard Areas," New York State Department of Environmental Conservation and New York State Office of Planning Services, Albany, New York, 13 pp., illus.

7. "Regulation of Flood Hazard Areas to Reduce Flood Losses," United States Water Resources Council, 2120 L Street, N.W., Washington, D. C. 20037. Available in two volumes: Volume 1, 578 pp. Volume 2, 389 pp., illus. Available for purchase from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, (Volume 1 costs $2.50; Volume 2 costs $2.00, FSN 5245-0010).

8. "The National Flood Insurance Program," U.S. Dept. of Housing and Urban Development, Washington, D. C., June, 1973.

APPENDIX D

OFFICE CONSOLIDATION OF ORDER
OF APPROVAL

October 29, 1952
as amended by
Order of Approval, July 2, 1956

Appendix D

Office Consolidation of Order of Approval[1]

The attached Office Consolidation has been prepared for the convenience of persons who have occasion to refer to these two Order of the Commission. It has no official status and in case of any discrepency between it and the actual Order, the terms of the Order shall prevail.

Office Consolidation

INTERNATIONAL JOINT COMMISSION

IN THE MATTER OF THE APPLICATIONS OF THE GOVERNMENT OF CANADA AND THE GOVERNMENT OF THE UNITED STATES OF AMERICA FOR AN ORDER OF APPROVAL OF THE CONSTRUCTION OF CERTAIN WORKS FOR DEVELOPMENT OF POWER IN THE INTERNATIONAL RAPIDS SECTION OF THE ST. LAWRENCE RIVER

ORDER OF APPROVAL

WHEREAS the Government of Canada and the Government of the United States of America under date of 30 June, 1952, have submitted Applications to the International Joint Commission (hereinafter referred to as the "Commission") for its approval of the construction, jointly be entities to be designated by the respective Governments, of certain works for the development of power in the International Rapids Section of the St. Lawrence River, these being boundary waters within the meaning of the Preliminary Article of the Boundary Waters Treaty of 11 January, 1909 (hereinafter referred to as the "Treaty"), and of the construction, maintenance and operation of such works subject to and under conditions specified in the Applications, and have requested that the Applications be considered by the Commission as in the nature of a joint application; and

WHEREAS pursuant to the aforementioned request of the two Governments, the Commission is considering the two Applications as in the nature of a joint application; and

---

[1]This Office Consolidation was provided by The International Joint Commission.

WHEREAS notices that the Applications had been filed were published in accordance with the Rules of Procedure of the Commission; and

WHEREAS Statements in Response to the Applications and Statements in Reply thereto by both Applicants were filed in accordance with the Rules of the Commission; and

WHEREAS pursuant to published notices, hearings were held by the Commission at Toronto, Ontario, on 23 July, 1952; at Ogdensburg, New York, on 24 July, 1952; at Cornwall, Ontario, on 25 July, 1952; at Albany, New York, on 3 September, 1952; at Montreal, Quebec, on 8 September, 1952; and at Washington, D.C., on 20 October, 1952; and

WHEREAS by reason of the said notices of the said applications and hearings, all persons interested were afforded convenient opportunities of presenting evidence to and being heard before the Commission; and

WHEREAS, pursuant to the said Applications, the hearings before, the evidence given, and material filed with the Commission, the Commission is satisfied that the proposed works and uses of the waters of the International Rapids Section comply with the principles by which the Commission is governed as adopted by the High Contracting Parties in Article VIII of the Treaty; and

WHEREAS the Commission has been informed that the Government of Canada has designated The Hydro-Electric Power Commission of Ontario as the entity to construct, maintain and operate the proposed works in Canada, and that the Government of the United States intends in due course to designate the entity to construct, maintain and operate the works in the United States; and

WHEREAS the program of construction of the works, as proposed by the Applicants, includes the removal of Gut Dam from the International Rapids Section and the Government of Canada has informed the Commission that it is its intention to take steps for the early removal of Gut Dam as soon as the construction of the proposed works is approved and as soon as river conditions and the protection of down river and other interests that will be affected during its removal will permit, thereby advancing the time of removal of Gut Dam; and

WHEREAS the Commission finds that suitable and adequate provision is made by the laws in Canada and by the Constitution and laws in the United States for the protection and indemnity of all interests on either side of the International Boundary which may be injured by reason of the construction, maintenance and operation of the works; and

WHEREAS the Commission finds that it has jurisdiction to hear and dispose of the Applications by approval thereof in the manner and subject to the conditions hereinafter set out;

NOW, THEREFORE, IT IS ORDERED that the construction, maintenance and operation jointly by The Hydro-Electric Power Commission of Ontario and an entity to be designated by the Government of the United States of America of certain works (hereinafter called "the works") in accordance with the "Controlled Single Stage Project (238-242)", which was part of the joint report dated 3 January, 1941, of the Canadian Temporary Great Lakes-St. Lawrence Basin Committee and the United States St. Lawrence Advisory Committee, containing the features described in Appendix "A" to this Order and shown in Appendix "B" to this Order, be and the same are hereby approved subject to the conditions enumerated below, namely,

(a) All interests on either side of the International Boundary which are injured by reason of the construction, maintenance and operation of the works shall be given suitable and adequate protection and indemnity in accordance with the laws in Canada or the Constitution and laws in the United States respectively, and in accordance with the requirements of Article VIII of the Treaty.

(b) The works shall be so planned, located, constructed, maintained and operated as not to conflict with or restrain uses of the waters of the St. Lawrence River for purposes given preference over uses of water for power purposes by the Treaty, namely, uses for domestic and sanitary purposes and uses for navigation, including the service of canals for the purposes of navigation, and shall be so planned, located, constructed, maintained and operated as to give effect to the provisions of this Order.

(c) The works shall be constructed, maintained and operated in such manner as to safeguard the rights and lawful interests of others engaged or to be engaged in the development of power in the St. Lawrence River below the International Rapids Section.

(d) The works shall be so designed, constructed, maintained and operated as to safeguard so far as possible the rights of all interests affected by the levels of the St. Lawrence River upstream from the Iroquois regulatory structure and by the levels of Lake Ontario and the lower Niagara River; and any change in levels resulting from the works

which injuriously affects such rights shall be subject to the requirements of paragraph (a) relating to protection and indemnification.

(e) The hydro-electric plants approved by this Order shall not be subjected to operating rules and procedures more rigorous than are necessary to comply with the provisions of the foregoing paragraphs (b), (c) and (d).

(f) Before The Hydro-Electric Power Commission of Ontario commences the construction of any part of the works, it shall submit to the Government of Canada, and before the entity designated by the Government of the United States commences the construction of any part of the works, it shall submit to the Government of the United States, for approval in writing, detailed plans and specifications of that part of the works located in their respective countries and details of the program of construction thereof or such details of such plans and specifications or programs of construction relating thereto as the respective Governments may require. If after any plan, specification or program has been so approved, The Hydro-Electric Power Commission of Ontario or the entity designated by the Government of the United States wishes to make any change therein, it shall, before adopting such change, submit the changed plan, specification or program for approval in a like manner.

(g) In accordance with the Applications, the establishment by the Governments of Canada and of the United States of a Joint Board of Engineers to be known as the St. Lawrence River Joint Board of Engineers (hereinafter referred to as the "Joint Board of Engineers") consisting of an equal number of representatives of Canada and the United States to be designated by the respective Governments, is approved. The duties of the Joint Board of Engineers shall be to review and coordinate, and, if both Governments so authorize, approve the plans and specifications of the works and the programs of construction thereof submitted for the approval of the respective Governments as specified above, and to assure the construction of the works in accordance therewith as approved. The Joint Board of Engineers shall consult with and keep the Board of Control, hereinafter referred to, currently informed on all matters pertaining to the water levels of Lake Ontario and the International Rapids Section and the regulation of the discharge of water from Lake Ontario and the flow of water through the International Rapids

Section, and shall give full consideration to any advice or recommendations received from the Board of Control with respect thereto.

(h) A Board of Control to be known as the International St. Lawrence River Board of Control (herein referred to as the "Board of Control") consisting of an equal number of representatives of Canada and of the United States, shall be established by this Commission. The duties of the Board of Control shall be to give effect to the instructions of the Commission as issued from time to time with respect to this Order.

During construction of the works the duties of the Board of Control shall be to keep itself currently informed of the plans of the Joint Board of Engineers insofar as these plans relate to water levels and the regulation of the discharge of water from Lake Ontario and the flow of water through the International Rapids Section, and to consult with and advise the Joint Board of Engineers thereon.

Upon completion of the works, the duties of the Board of Control shall be to ensure that the provisions of this Order relating to water levels and the regulation of the discharge of water from Lake Ontario and the flow of water through the International Rapids Section as herein set out are complied with, and The Hydro-Electric Power Commission of Ontario and the entity designated by the Government of the United States shall duly observe any direction given them by the Board of Control for the purpose of ensuring such compliance. The Board of Control shall report to the Commission at such times as the Commission may determine.

In the event of any disagreement amongst the members of the Board of Control which they are unable to resolve, the matter shall be referred by them to the Commission for decision. The Board of Control may, at any time, make representations to the Commission in regard to any matter affecting or arising out of the terms of this Order with respect to water levels and the regulation of the said discharge and flow.

(i) Upon the completion of the works, the discharge of water from Lake Ontario and the flow of water through the International Rapids Section shall be regulated to meet the requirements of conditions

(b), (c), and (d) hereof; shall be regulated within a range of stage from elevation 244.0 feet* (navigation season) to elevation 248.0 feet, as nearly as may be; and shall be regulated in accordance with the criteria set forth in the Commission's letters of 17 March 1955 to the Governments of Canada and the United States of America and approved by the said governments in their letters of 3 December 1955 and qualified, by the terms of separate letters from the Government of Canada and the Government of the United States of America dated 11 April 1956 and 1 May 1956, respectively, to the extent that these letters agree that the criteria are intended to establish standards which would be maintained with the minimum variation. The project works shall be operated in such a manner as to provide no less protection for navigation and riparian interests downstream than would have occurred under pre-project conditions and with supplies of the past as adjusted, as defined in criterion (a) herein. The Commission will indicate in an appropriate fashion, as the occasion may require, the inter-relationship of the criteria, the range of elevations and the other requirements.

As amended 2 July 1956

The criteria are as follows:

(a) The regulated outflow from Lake Ontario from 1 April to 15 December shall be such as not to reduce the minimum level of Montreal Harbour below that which would have occurred in the past with the supplies to Lake Ontario since 1860 adjusted to a condition assuming a continuous diversion out of the Great Lakes Basin of 3,100 cubic feet per second at Chicago and a continuous diversion into the Great Lakes Basin of 5,000 cubic feet per second from the Albany River Basin (hereinafter called the "supplies of the past as adjusted").

(b) The regulated winter outflows from Lake Ontario from 15 December to 31 March shall be as large as feasible and shall be maintained so that the difficulties of winter power operation are minimized.

(c) The regulated outflow from Lake Ontario during the annual spring break-up in Montreal Harbour and in the river downstream shall not be greater than would have occurred assuming supplies of the past as adjusted.

---

* All elevations mentioned in this Order are stated in relation to the United States Lake Survey 1935 datum.

(d) The regulated outflow from Lake Ontario during the annual flood discharge from the Ottawa River shall not be greater than would have occurred assuming supplies of the past as adjusted.

(e) Consistent with other requirements, the minimum regulated monthly outflow from Lake Ontario shall be such as to secure the maximum dependable flow for power.

(f) Consistent with other requirements, the maximum regulated outflow from Lake Ontario shall be maintained as low as possible to reduce channel excavations to a minimum.

(g) Consistent with other requirements, the levels of Lake Ontario shall be regulated for the benefit of property owners on the shores of Lake Ontario in the United States and Canada so as to reduce the extremes of stage which have been experienced.

(h) The regulated monthly mean level of Lake Ontario shall not exceed elevation 248.0 with the supplies of the past as adjusted.

(i) Under regulation, the frequency of occurrences of monthly mean elevations of approximately 247.0 and higher on Lake Ontario shall be less than would have occurred in the past with the supplies of the past as adjusted and with present channel conditions in the Galops Rapids Section of the Saint Lawrence River.*

(j) The regulated level of Lake Ontario on 1 April shall not be lower than elevation 244.0. The regulated monthly mean level of the lake from 1 April to 30 November shall be maintained at or above elevation 244.0.

(k) In the event of supplies in excess of the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to the riparian owners upstream and downstream. In the event of supplies less than the supplies

---

* "present channel conditions" refers to conditions as of March 1955.

of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to navigation and power interests.

The flow of water through the International Rapids Section in any period shall equal the discharge of water from Lake Ontario as determined for that period in accordance with a plan of regulation which, in the judgment of the Commission, satisfies the afore-mentioned requirements, range of stage and criteria and when applied to the channels as determined in accordance with Appendix A hereto produces no more critical governing velocities than those specified in that appendix, nor more critical governing water surface profiles than those established by Plan of Regulation 12-A-9, when applied to the channels as determined in accordance with Appendix A hereto, and shall be maintained as uniformly as possible throughout that period.

Subject to the requirements of conditions (b), (c) and (d) hereof, and of the range of stage, and criteria, above written, the Board of Control, after obtaining the approval of the Commission, may temporarily modify or change the restrictions as to discharge of water from Lake Ontario and the flow of water through the International Rapids Section for the purpose of determining what modifications or changes in the plan of regulation may be advisable. The Board of Control shall report to the Commission the results of such experiments, together with its recommendations as to any changes or modifications in the plan of regulation. When the plan of regulation has been perfected so as best to meet the requirements of all interests, within the range of stage and criteria above defined, the Commission will recommend to the two Governments that it be made permanent and, if the two Governments thereafter agree, such plan of regulation shall be given effect as if contained in this order.

(j) Subject as hereinafter provided, upon completion of the works, the works shall be operated initially for a test period of ten years, or such shorter period as may be approved by the Commission with the forebay water level at the power houses held at a maximum elevation of 238.0 feet, sea level datum. Subject to the requirements of paragraphs (b), (c) and (d) hereof, the Board of Control, after obtaining the approval of the Commission, may temporarily modify or change the said forebay water

level in order to carry out experiments for the purpose of determining whether it is advisable to increase the forebay water level at the power houses to a maximum elevation exceeding 238.0 feet. If the Board of Control, as a result of these experiments considers that operation during this test period at a maximum elevation exceeding 238.0 feet would be advisable, and so recommends, the Commission will consider authorizing operation during this test period at a maximum elevation exceeding 238.0 feet. At the end of this test period, the Commission will make such recommendations to the two Governments with respect to a permanent forebay water level as it deems advisable or it may recommend an extension of the test period. Such of these recommendations as the two Governments thereafter agree to adopt shall be given effect as if contained in this Order.

(k) The Hydro-Electric Power Commission of Ontario and the entity designated by the Government of the United States shall maintain and supply for the information of the Board of Control accurate records relating to water levels and the discharge of water through the works and the regulation of the flow of water through the International Rapids Section, as the Board of Control may determine to be suitable and necessary, and shall install such gauges, carry out such measurements, and perform such other services as the Board may deem necessary for these purposes.

(l) The Board of Control shall report to the Commission as of 31 December each year on the effect, if any, of the operation of the downstream hydro-electric power plants and related structures on the tailwater elevations at the hydro-electric power plants approved by this Order.

(m) The Government of Canada shall proceed forthwith to carry out its expressed intention to remove Gut Dam.

AND IT IS FURTHER ORDERED that the allocation set our in Appendix "C" of the costs of constructing, maintaining and operating the works approved by this Order between The Hydro-Electric Power Commission of Ontario and the entity to be designated by the Government of the United States be and the same is hereby approved but such approval shall not preclude the Applicants from submitting to the Commission for approval any variation in the said allocation that may be agreed upon between them as being appropriate or advisable.

AND IT IS FURTHER ORDERED that the Commission retains jurisdiction over the subject matter of these Applications, and may, after giving such notice and opportunity to all interested parties to make representations as the Commission deems appropriate, make such further Order or Orders relating thereto as may be necessary in the judgment of the Commission.

Signed at Montreal, this 29th day of October, 1952.

(Signed) A. G. L. McNaughton

A. O. Stanley

Geo. Spence

Eugene W. Weber

J. Lucien Dansereau

Commissioner McWhorter dissenting.

APPENDIX E

DESCRIPTION OF PLAN OF CONTROL

1958-D

APPENDIX E

Description of Plan of Control 1958-D

I. Criteria Under Which Plan 1958-D Operates

Plan 1958-D was developed to respect the criteria set forth in the Order of Approval of 29 October 1952 (See Appendix D).

II. General[1]

Artificial control of the outflows and levels of Lake Ontario must follow a plan that is designed to satisfy the criteria and other requirements that have been established to protect or to provide advantages to the various interests concerned. By testing a plan over the period of record, employing the supplies of the past as adjusted, assessment may be made of the degree to which a plan will satisfy the criteria and other requirements and of the probable effects of regulation under the plan in the future.

Plan 1958-D consists of a supply indicator, two basic rule curves, shown as Figures 1 and 2, seasonal adjustments tabulated on Table 1 and a number of maximum and minimum outflow limitations shown on Figure 3 and Table 1.[2] In the application of Plan 1958-D, the regulated Lake Ontario outflow is obtained in three steps. In the first step the basic regulated outflow is derived from the family of curves on Figure 1 or Figure 2 which shows the basic regulated outflow as a function of the end-of-period Lake Ontario level and the "adjusted supply indicator." In the second step the basic regulated outflow is adjusted by applying the seasonal adjustment tabulated in Table 1. In the third step the resultant seasonal adjusted outflow is compared with the maximum and minimum outflow limitations shown on Figure 3 and Table 1 which have been chosen to

---

[1]This description is taken primarily from Regulation of Lake Ontario (Plan 1958-D), Report to the International Joint Commission by the St. Lawrence Board of Control, July 1963.

[2]Figures and Tables referenced refer to those included in this Appendix.

MONTH	QUARTER	WEIGHTED NORMAL SUPPLY	SEASONAL ADJUSTMENT TO BASIC RULE OUTFLOW	MINIMUM FLOW LIMITATIONS		MAXIMUM FLOW LIMITATIONS		
				Add to Supply Indicator at End of Preceding Period (P)*	Minimum (M)	For Channel Design (L)	For Ice Formation Lachine (I)	Add to Supply Indicator at End of Preceding Period (P)
1	2	3	4	5	6	7	8	9
JANUARY	1	234	0	-	210		-	-
	2	234	- 6	-	210		-	-
	3	233	- 6	-	210		-	-
	4	233	- 6	-	210		-	-
FEBRUARY	1	233	- 6	-	207		-	248
	2	233	- 6	-	207		-	248
	3	233	- 6	-	207		-	248
	4	233	- 6	-	207		-	248
MARCH	1	233	- 6	-	204		-	248
	2	235	- 6	-	204		-	248
	3	237	- 6	-	204		-	248
	4	242	- 6	-	204		-	248
APRIL	1	246	- 8	-	188		-	248
	2	249	- 10	-	188		-	253
	3	252	- 12	-	188		-	257
	4	254	- 14	-	188		-	259
MAY	1	257	- 16	-	188		-	261
	2	258	- 18	-	188		-	263
	3	260	- 20	227*	188		-	265
	4	261	- 20	232*	188		-	266
JUNE	1	262	- 20	237*	190		-	267
	2	262	- 20	242*	190		-	267
	3	263	- 20	245*	190		-	268
	4	263	- 20	247*	190		-	268
JULY	1	262	- 18	249*	193		-	268
	2	262	- 16	251*	193		-	267
	3	261	- 14	252*	193		-	266
	4	259	- 12	253*	193		-	265
AUGUST	1	258	- 10	254*	193		-	-
	2	256	- 8	255*	193		-	-
	3	254	- 6	256*	193		-	-
	4	252	- 4	256*	193		-	-
SEPTEMBER	1	250	- 2	256*	193		-	-
	2	248	0	256*	193		-	-
	3	246	+ 2	255*	193		-	-
	4	244	+ 2	252*	193		-	-
OCTOBER	1	243	+ 2	249*	193		-	-
	2	241	+ 2	247*	193		-	-
	3	239	+ 2	245*	193		-	-
	4	238	+ 4	243*	193		-	-
NOVEMBER	1	237	+ 4	241*	198		-	-
	2	236	+ 6	240*	198		-	-
	3	235	+ 6	239*	198		-	-
	4	235	+ 8	238*	198		-	-
DECEMBER	1	235	+ 8	238*	210		-	-
	2	235	+ 8	238*	210		-	-
	3	234	+ 6	-	210		280 from Lake St. Louis	-
	4	234	+ 6	-	210			-

PLATE 2

When outflow from Lake St. Louis for previous quarter exceeds 345,000 cfs.

*If sum exceeds (225 - 1/6 I) where I is the difference between the outflows of Lake St. Louis and Lake Ontario for preceding quarter, use (225 - 1/6 I) (P).

Table 1. Table of Normal Supply Indices and Flow Limitations in Thousands of Cubic Feet Per Second (Source: Regulation of Lake Ontario - Plan 1958-D, The International St. Lawrence River Board of Control.)

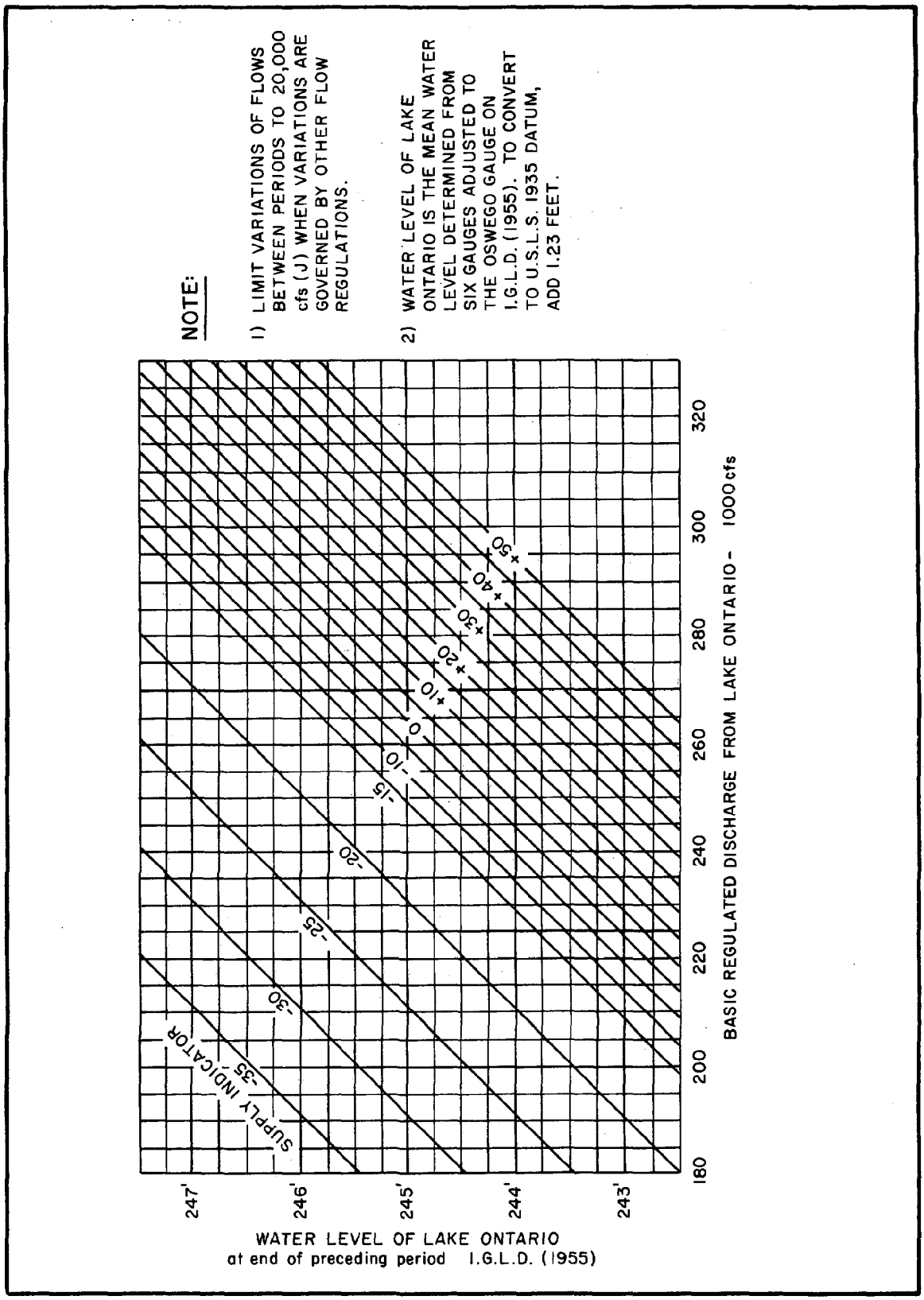


Figure 1. Basic Rule Curve (February - July inclusive) (Source: Regulation of Lake Ontario, Plan 1958-D The International St. Lawrence River Board of Control, 1963).

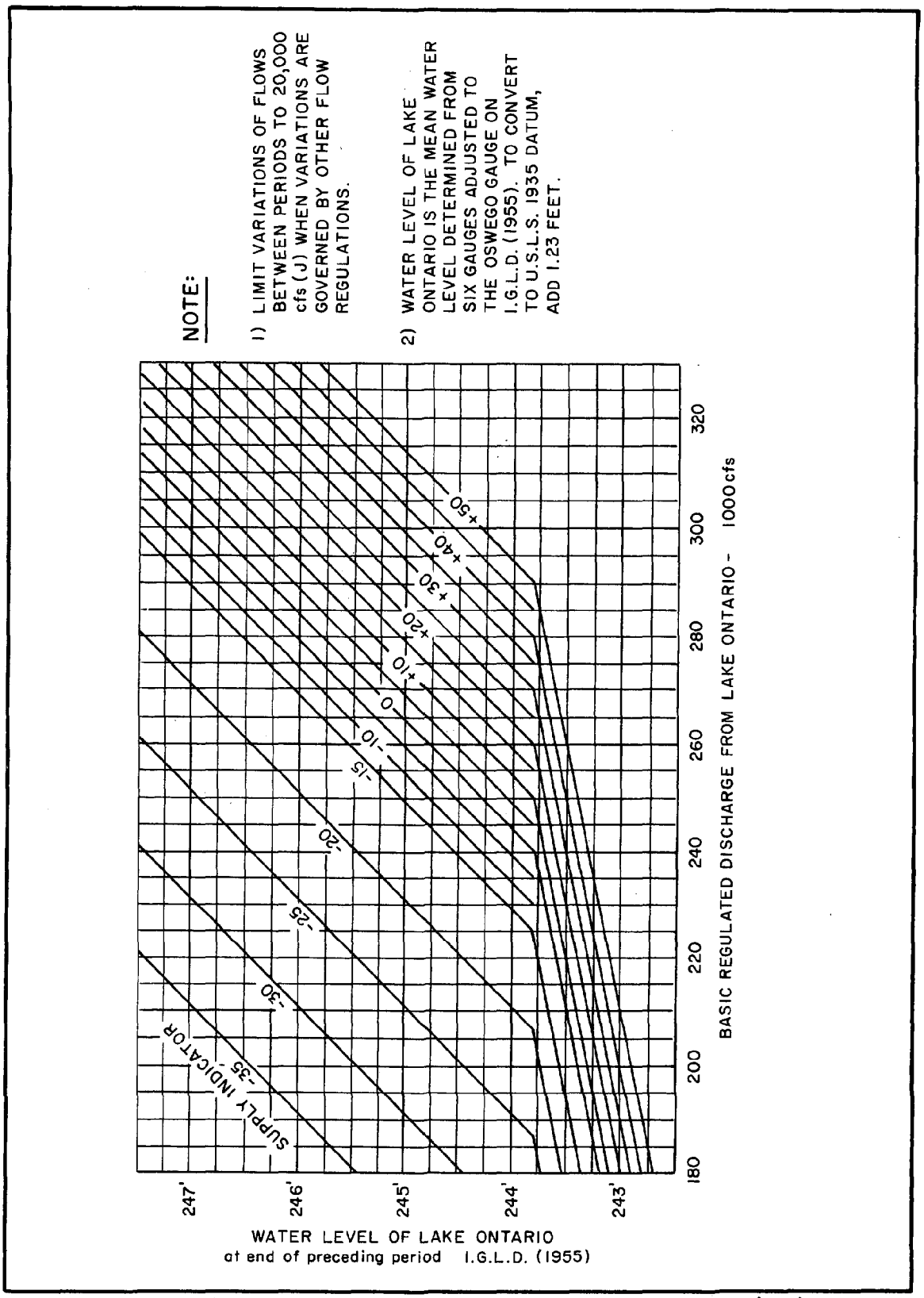


Figure 2. Basic Rule Curve (August - January Inclusive) (Source: Regulation of Lake Ontario, Plan 1958-D The International St. Lawrence River Board of Control, 1963)

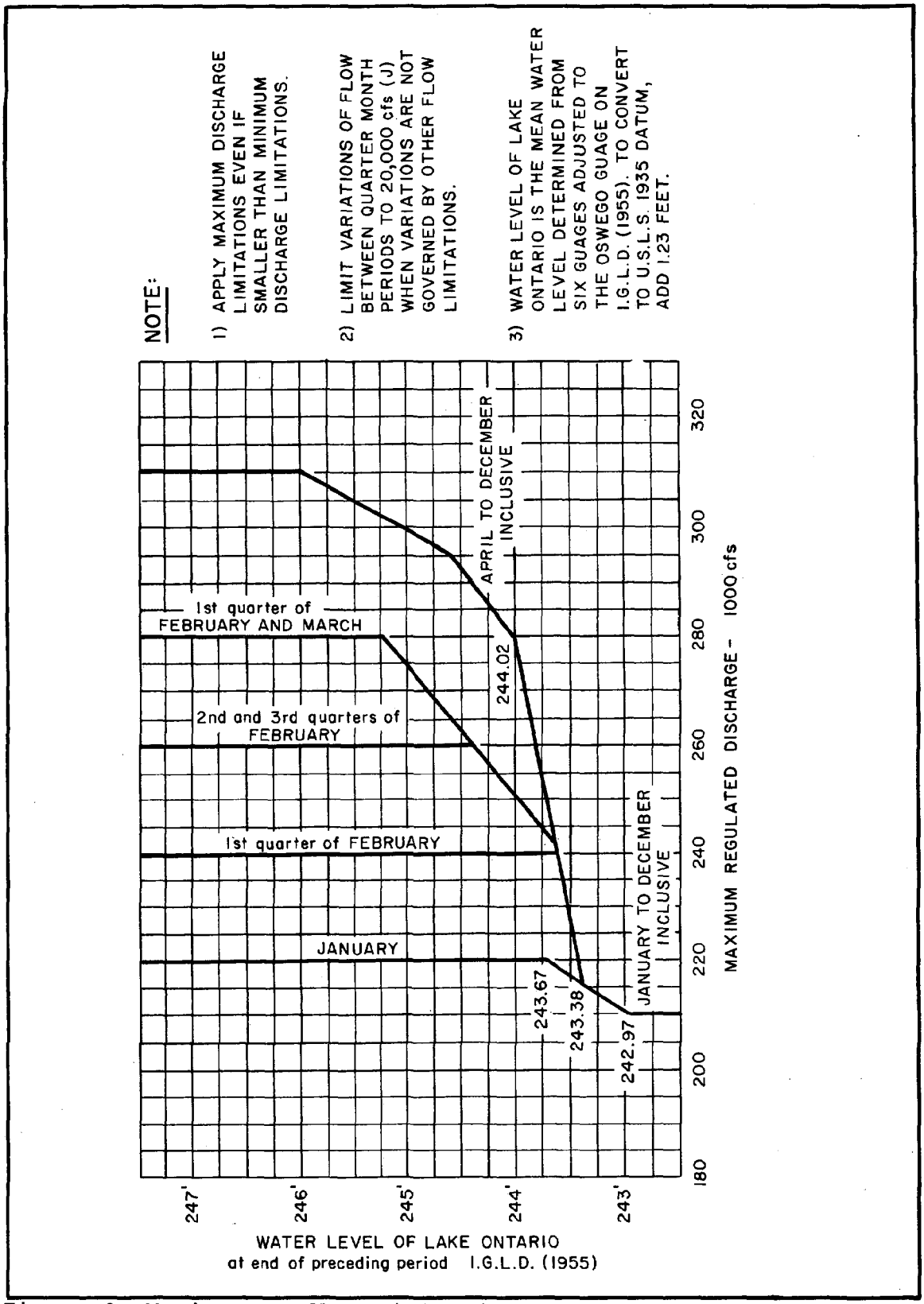


Figure 3. Maximum Outflow Limitations as Related to Water Levels (Source: Regulation of Lake Ontario - Plan 1958-D, The International St. Lawrence River Board of Control)

meet various requirements of regulation. These outflow limitations vary throughout the year. If the seasonal adjusted outflow is between the minimum and maximum limitations for the period, it is adopted as the regulated outflow. If it is higher than the maximum limitation or lower than the minimum limitation, the applicable outflow limitation is adopted as the regulated outflow. A sample computation sheet and explanation is presented on Figure 4.

The features and procedures of Plan 1958-D[3] are described below.

III. Supply Indicies

To make most effective use of the storage available on Lake Ontario, it is necessary to vary the regulated outflow according to some estimate of future water supply conditions. Approximately 85% of the average water supply to Lake Ontario comes from the upper Great Lakes where it is subjected to the regulatory influence of the large surface areas of the lakes. This component of the water supply changes very slowly so that reasonably accurate seasonal forecasts of it are practicable. The remaining 15% of the average water supply originates in the local drainage basin and fluctuates widely and it is not possible to predict this component with any degree of accuracy with presently available data and techniques.

In the selection of a factor to be used as an indication of future supplies, the following considerations were taken into account:

(i) It must use data which have some relationship to supply conditions and which are available for the period of record. The data should be adjusted to present conditions of diversions and should be properly coordinated. At present the best available data are the total water supplies to Lake Ontario.

(ii) Because the water supply to Lake Ontario from the upper Great Lakes varies approximately with the quantity of water stored in the lakes which must eventually reach Lake Ontario, it is possible to get a fairly good indication of future supplies by a procedure which gives due weight to the magnitude and sequence of the total water supplies that have already occurred. The supplies must be weighted in such a manner that the resultant supply indicator is sensitive enough to indicate the beginning of a significant long-term

---

[3]Plan 1958-C was revised to form Plan 1958-D with the explicit objective of improving the water levels in Montreal Harbour to the extent consistent with all requirements of the Orders of Approval.

COLUMN NUMBER	PROCEDURE	Example for 7 April 1937
1.	The regulation periods are quarter month periods as defined in paragraph 13.	
2.	Supply to Lake Ontario = $\bar{I}$ = Outflow plus change in storage when lake level rises during period and minus change in storage when lake level falls. These supplies were determined as described in paragraphs 28 and 29 and are tabulated in Table 8 Volumn 2 of the report on Regulation Plan 1958-A.	
3.	16.5 x Weighted Supply = "KO" forms part of the routing procedure described in paragraphs 36 to 38. To compute KO, subtract the value of O (Column 4) for previous period from the value of KO for previous period and add the value of $\bar{I}$ (Column 2) for current period.	3636 - 220 + 273 = 3688
4.	Weighted Supply = "O" also forms part of the routing procedure and is derived by dividing value in Column 3 by 16.5.	$\frac{3688}{16.5} = 223$
5.	Weighted Normal Supply = These data are tabulated on Plate 3 for each regulation period.	
6.	Supply Indicator. Subtract value in Column 5 from that in Column 4.	223 - 246 = - 22
7.	Change in Supply Indicator in Three Months.	- 22 - (- 34) = + 12
8.	Adjustment. Add values in Column 7 for three preceding periods to value for period in question and divide by 4.5. The adjustment is limited in application to magnitudes of - 7,000 cfs and + 11,000 cfs, (see paragraph 41). The adjustment is also held constant during the winter and early spring; the value during this period is dependent upon the value of the adjustment during the third quarter of December, which was + 7,000 cfs.	$\frac{26 + 23 + 15 + 12}{4.5} = 17$
9.	Adjusted Supply Indicator. Add value in Column 8 to that in Column 6.	- 22 + 7 = - 15
10.	With adjusted Supply Indicator (Column 9) for previous period and end of period level (Column 16) for previous period, enter the appropriate Basic Rule Curve (Plate 1A or 1B) and read discharge from horizontal scale.	With elevation of 244.02 and adjusted supply indicator of - 15, basic regulated discharge from basic curve is 229.
11.	Seasonal Adjustment. These data are tabulated on Plate 3 for each period.	
12.	Seasonal Adjusted Outflow is obtained by adding value in Column 10 to that in Column 11.	229 + (- 8) = 221
13.	Discharge with limitations. The limitations are tabulated on Plate 3. There are three types of maximum limitations and two types of minimum limitations. For January 4, only two limitations may apply: a minimum designated (M) and a maximum designated (L). Since the seasonal adjusted outflow 222 (Column 12) exceeds the maximum limitation 220^L (derived from Plate 2 with elevation 243.94), use 220^L. For April 1, three limitations may apply: a minimum (M) and two maxima (L) and (P). The (L) from Plate 2 is 280^L and the (P) maximum is 248 plus the supply indicator (Column 6) of March 4 of - 22, which gives 226^P. The seasonal adjusted outflow is 221, therefore use 221. For June 1, four limitations may apply: two minima (M) and (P) and two maxima, (L) and (P). The (L) from Plate 2 is 304^L and since the Lake St. Louis regulated outflow (298) for the previous period does not exceed 345, the maximum (P) is not applicable. The (M) is 190^M and the minimum (P) 237 - 15 = 222^P with a maximum limit of (225 - 1/6 I) or 214. The seasonal adjusted outflow is 232 which is greater than the minima and less than the maximum, therefore use 232. For October 2, three limitations may apply: two minima (M) and (P) and a maximum (L). The (M) is 193^M, the (P) is 247 - 18 = 229 with a maximum of (225 - 1/6 I) which is (225 - 3) or 222^P. Since the seasonal adjusted flow, 217, is less than minimum (P) 222, use 222^P.	
14.	Change in Storage, Column 2 minus Column 13.	273 - 221 = + 52
15.	Change in Storage in Feet, use conversion Table on Plate 4.	+ 52 = + 0.16 feet
16.	End of Period Water Level. Add value in Column 15 to end of previous period level.	244.02 + 0.16 = 244.18
17.	Mean for Period. Average of end of current and previous period level.	$\frac{244.02 + 244.18}{2} = 244.10$
18.	Recorded adjusted Lake Ontario outflows were determined as described in paragraphs 22 and 23.	
19.	Recorded adjusted Lake St. Louis outflows were determined as described in paragraphs 24 and 25.	
20.	Mean outflows from Lake St. Louis with Lake Ontario regulated under Plan 1958-D. Add difference between values in Columns 19 and 18 to value in Column 13.	(278 - 225) + 221 = 274

Figure 4. Example of Sample Computation Sheet (Source: Regulation of Lake Ontario, Plan 1958-D, International St. Lawrence River Board of Controls, 1963).

Note: 1. All references in this figure are to the source document.
2. These computations were made to a higher degree of accuracy using an electronic computer and therefore totals may not agree exactly due to rounding.

REGULATION PERIOD 1937	SUPPLY DURING PERIOD	SUPPLY INDICATOR AT END-OF-PERIOD -- 1000 CFS				ADJUSTMENT OF SUPPLY INDICATOR AT END-OF-PERIOD -- 1000 CFS			UNDER PLAN 1958-D								RECORDED ADJUSTED OUTFLOWS - 1000 CFS		MEAN OUTFLOW FROM LAKE ST. LOUIS WITH LAKE ONTARIO REGULATED UNDER PLAN 1958-D
									OUTFLOWS FROM LAKE ONTARIO -- 1000 CFS				CHANGE IN STORAGE		WATER LEVELS OF LAKE ONTARIO				
		16.5 X WEIGHTED SUPPLY = "KO"	WEIGHTED SUPPLY "O"	WEIGHTED NORMAL SUPPLY	SUPPLY INDICATOR	CHANGE IN SUPPLY INDICATOR IN THREE MONTHS	ADJUSTMENT	ADJUSTED SUPPLY INDICATOR	FROM BASIC CURVE	SEASONAL ADJUSTMENT	SEASONAL ADJUSTED	WITH LIMITATIONS	1000 CFS	FEET	END OF PERIOD	MEAN FOR PERIOD	FROM LAKE ONTARIO	FROM LAKE ST. LOUIS	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jan 1	249	3299	200	234	- 34	+ 7	+ 7	- 27	180	0	180	210[M]	+ 39	+ 0.12	243.40	243.34	201	247	256
2	287	3386	205	234	- 29	+ 12	+ 7	- 22	180	- 6	174	210[M]	+ 77	+ 0.24	243.64	243.52	207	256	259
3	306	3487	211	233	- 22	+ 17	+ 7	- 15	183	- 6	177	210[M]	+ 96	+ 0.30	243.94	243.79	210	265	265
4	277	3553	215	233	- 18	+ 21	+ 7	- 11	228	- 6	222	220[L]	+ 57	+ 0.18	244.12	244.03	213	259	266
Feb 1	244	3582	217	233	- 16	+ 20	+ 7	- 9	235	- 6	229	229	+ 15	+ 0.05	244.17	244.14	212	273	290
2	233	3597	217	233	- 15	+ 20	+ 7	- 8	238	- 6	232	232[P]	+ 1	0	244.17	244.17	217	252	267
3	231	3610	219	233	- 14	+ 22	+ 7	- 7	239	- 6	233	233[P]	- 2	- 0.01	244.16	244.16	215	246	264
4	270	3662	222	233	- 11	+ 26	+ 7	- 4	240	- 6	234	234[P]	+ 36	+ 0.11	244.27	244.22	222	255	267
Mar 1	237	3677	223	233	- 10	+ 28	+ 7	- 3	245	- 6	239	237[P]	0	0	244.27	244.27	221	262	278
2	203	3657	222	235	- 13	+ 26	+ 7	- 6	246	- 6	240	238[P]	- 35	- 0.11	244.16	244.22	219	264	283
3	222	3657	222	237	- 15	+ 23	+ 7	- 8	241	- 6	235	235[P]	- 13	- 0.04	244.12	244.14	222	250	263
4	200	3636	220	242	- 22	+ 15	+ 7	- 15	238	- 6	232	232	- 32	- 0.10	244.02	244.07	216	246	262
Apr 1	273	3688	223	246	- 22	+ 12	+ 7	- 15	229	- 8	221	221	+ 52	+ 0.16	244.18	244.10	225	278	274
2	258	3723	226	249	- 23	+ 6	+ 7	- 16	233	- 10	223	223	+ 35	+ 0.11	244.29	244.24	226	306	303
3	322	3819	231	252	- 21	+ 1	+ 7	- 14	232	- 12	220	220	+102	+ 0.32	244.61	244.45	226	301	295
4	311	3899	236	254	- 18	0	+ 7	- 11	242	- 14	228	228	+ 83	+ 0.26	244.87	244.74	231	326	323
May 1	286	3948	239	257	- 18	- 2	+ 7	- 11	250	- 16	234	234	+ 52	+ 0.16	245.03	244.95	237	336	333
2	256	3965	240	258	- 18	- 3	- 1	- 19	254	- 18	236	236	+ 20	+ 0.06	245.09	245.06	239	344	341
3	310	4035	244	260	- 15	- 1	- 1	- 16	237	- 20	217	217	+ 93	+ 0.29	245.38	245.24	245	337	309
4	263	4053	246	261	- 15	- 4	- 2	- 17	254	- 20	234	234	+ 29	+ 0.09	245.47	245.42	246	310	298
Jun 1	247	4055	246	262	- 16	- 6	- 3	- 19	252	- 20	232	232	+ 15	+ 0.05	245.52	245.50	247	300	285
2	247	4056	246	262	- 16	- 3	- 3	- 19	245	- 20	225	225	+ 22	+ 0.07	245.59	245.56	247	291	269
3	277	4087	248	263	- 15	0	- 3	- 18	246	- 20	226	226	+ 51	+ 0.16	245.75	245.67	245	283	264
4	246	4085	248	263	- 15	+ 7	0	- 15	254	- 20	234	234	+ 12	+ 0.04	245.79	245.77	246	278	266
Jul 1	231	4069	247	262	- 15	+ 7	+ 2	- 13	265	- 18	247	247	- 16	- 0.05	245.74	245.76	247	273	273
2	228	4050	245	262	- 17	+ 6	+ 4	- 13	266	- 16	250	250	- 22	- 0.07	245.67	245.70	244	265	271
3	232	4037	245	261	- 16	+ 5	+ 6	- 10	264	- 14	250	250	- 18	- 0.06	245.61	245.64	248	266	268
4	233	4025	244	259	- 15	+ 3	+ 5	- 10	266	- 12	254	254	- 21	- 0.07	245.54	245.58	249	267	272
Aug 1	226	4007	243	258	- 15	+ 3	+ 4	- 11	265	- 10	255	255	- 29	- 0.09	245.45	245.50	243	263	275
2	243	4007	243	256	- 13	+ 5	+ 4	- 9	262	- 8	254	254	- 11	- 0.03	245.42	245.44	244	262	272
3	192	3956	240	254	- 14	+ 1	+ 3	- 11	263	- 6	257	257	- 65	- 0.20	245.22	245.32	241	265	281
4	221	3938	239	252	- 13	+ 2	+ 2	- 11	257	- 4	253	253	- 32	- 0.10	245.12	245.17	238	257	272
Sep 1	186	3885	235	250	- 15	+ 1	+ 2	- 13	255	- 2	253	253	- 67	- 0.21	244.91	245.02	234	250	269
2	186	3836	232	248	- 16	0	+ 1	- 15	249	0	249	249	- 63	- 0.20	244.71	244.81	234	248	263
3	170	3773	229	246	- 17	- 2	0	- 17	243	+ 2	245	245	- 75	- 0.23	244.48	244.60	233	249	261
4	194	3738	227	244	- 17	- 2	- 1	- 18	233	+ 2	235	233	- 41	- 0.13	244.35	244.42	226	244	253
Oct 1	193	3705	224	243	- 18	- 3	- 2	- 20	226	+ 2	228	228	- 35	- 0.11	244.24	244.30	225	243	246
2	159	3639	221	241	- 20	- 3	- 2	- 22	215	+ 2	217	222[P]	- 63	- 0.20	244.04	244.14	223	243	242
3	239	3658	222	239	- 17	- 1	- 2	- 19	203	+ 2	205	222[P]	+ 17	+ 0.05	244.09	244.06	223	241	240
4	241	3677	223	238	- 15	0	- 2	- 17	217	+ 4	221	222[P]	+ 19	+ 0.06	244.15	244.12	225	253	250
Nov 1	192	3646	221	237	- 16	- 1	- 1	- 17	226	+ 4	230	230	- 38	- 0.12	244.03	244.09	225	258	263
2	268	3693	224	236	- 12	+ 1	0	- 12	224	+ 6	230	230	+ 38	+ 0.12	244.15	244.09	221	260	269
3	192	3661	222	235	- 13	+ 1	0	- 13	235	+ 6	241	241	- 49	- 0.15	244.00	244.08	225	290	306
4	210	3649	221	235	- 14	- 1	0	- 14	231	+ 8	239	239	- 29	- 0.09	243.91	243.96	227	278	290
Dec 1	223	3651	221	235	- 14	+ 1	0	- 14	228	+ 8	236	236	- 13	- 0.04	243.87	243.89	224	263	275
2	175	3605	218	235	- 17	- 1	0	- 17	227	+ 8	235	235	- 60	- 0.19	243.68	243.78	224	259	270
3	234	3620	219	234	- 15	+ 2	0	- 15	207	+ 6	213	215[J]	+ 19	+ 0.06	243.74	243.71	219	252	248
4	165	3566	216	234	- 18	- 1	0	- 18	219	+ 6	225	225	- 60	- 0.19	243.55	243.64	214	245	256

Figure 4 (continued). Example of Sample Computation Sheet.

supply change but not so sensitive as to give any appreciable weight to short-term supply changes which provide an erroneous indication of future supplies, such as those caused by ice jams in the Niagara River and winter floods and early freeze-ups in the local drainage basin.

(iii) The computation of the supply indicator should be simple. Since the data are used only as an indication of future supplies, a great amount of elaboration is not required.

A simple method of weighting past supplies is by means of standard routing procedures based on the storage equation:

Inflow - Outflow = Changes in storage

By manipulation of the storage equation, the following equality can be obtained:

$$O_2 = \frac{(\bar{I} - O_1) + kO_1}{k}$$

where O_2 = outflow at the end of the period

O_1 = outflow at the end of the preceding period

$\bar{I}$ = mean supply for period

$k = \frac{\text{change in storage}}{\text{change in outflow}} + 0.5$

This equation is used to compute progressively the routed outflows which by definition are the "weighted supplies."

The value of k can be chosen to give any desired weight to the sequence and magnitude of past supplies. If k were made equal to 1, the weighted supply would equal the mean supply for the preceding period. As k is increased, more weight is given to the more remote supplies and the weighted supply becomes less sensitive to recent supply changes.

As previously defined, $k = \frac{\text{change in storage}}{\text{change in outflow}} + 0.5$.

It can be seen that k is constant when both the storage and outflow bear a linear relationship to each other. For convenience in setting outflow limitations (discussed hereafter), the value of k was chosen so that the weighted supply would approximate the preproject outflow from Lake Ontario with no ice retardation. For this condition with a one-foot change in stage on Lake Ontario -

change in outflow = 20,000 cubic feet per second approximately

change in storage = 80,000 cubic feet per second for one month

= 320,000 cubic feet per second for one quarter-month

= 348,000 cubic feet per second for one week

Use of these quantities results in values of k equal to -

k = 4.5 for a period of a month
k = 16.5 for a period of a quarter-month
k = 17.85 for a period of a week

The weight given to the supply for each month in deriving the weighted supply using these values of k is shown in Table 2.

Table 2. Weights Given to Supply For Months Past

Number of Months in Past (t)	Weight Given to Supply of t^{th} Month in Computing Weighted Supply
1	0.2212
2	0.1723
3	0.1341
4	0.1045
5	0.0814
6	0.0634
7	0.0493
8	0.0385
9	0.0299
10	0.0233
11	0.0182
12	0.0141
remainder beyond 12	0.0498

The "weighted normal supplies" are the weighted supplies derived from the long-term average supplies for each period of the year. The weighted normal supplies are tabulated in Column 3 of Table 1. The "supply indicator" is defined as the difference between the weighted supply and the weighted

normal supply.

As an index of future supplies, the supply indicator is not sufficiently sensitive to detect all significant supply changes, so an adjustment is required. In Plan 1958-D, this adjustment is determined, except during the winter and early spring, by computing the change in the supply indicator from the indicator value occurring twelve quarter-months previously, averaging these changes for the last four quarter-month periods (so it would not be too dependent on isolated values), and multiplying the result by a factor of 8/9. During the winter and early spring the adjustment is held constant and is determined by averaging changes in the supply indicator for the eight quarter-month periods ending at the conclusion of the second quarter of December, and multiplying the result by 8/9. The constant adjustment is applied to the varying supply indicator during the period from the third quarter of December to the first quarter of April, inclusive, if negative and, if zero or positive, to the first quarter of May, inclusive. Adjustments to the supply indicator are limited in application to magnitudes of -7,000 cubic feet period second and +11,000 cubic feet period second.

The supply indicator with the adjustment applied is defined as the "adjusted supply indicator." During the summer and fall months when the limitations on the adjustment do not apply, the supply indicator is approximately equal to the deviation from normal of the average supply for the past three months. Although the adjusted supply indicator is in general quite similar to the adjusted deviation of the supply index from normal used in Plan 1958-C, there are significant differences in the computation of the adjustments. These differences have been made in order to make the adjusted supply indicator more sensitive to significant supply changes and less sensitive to spurious supply changes, such as those caused by winter floods in the local drainage basin, than the adjusted deviation of the supply index from normal.

IV. Basic Rule Curves

Each of the basic rule curves shown on Figures 1 and 2 consists of a family of straight lines which gives the regulated outflow for each period of the year as a function of the water level of the lake and the adjusted supply indicator at the end of the preceding period. On Figure 1 which is applicable to the period February through July, the curve of zero adjusted supply indicator approximates the preproject outflow rating curve lowered by one foot. The second basic rule curve, shown on Figure 2, covers the period August through January and is identical to the basic rule curve for the period February through July above elevation 243.80. Below elevation 242.80, the lines have

a slope of 100,000 cubic feet per second per foot, which permits the retention of more stored water at low lake levels than would result from the use of Figure 1 throughout the year.

The lines for all indicators greater or less than zero are parallel to the zero line. The spacing of the lines was determined by successive trials. Except during very low supply conditions, the outflow is changed by 1000 cubic feet per second for every 1000 cubic feet per second change in the adjusted supply indicator. This small rate of change is possible because the line of zero deviation is considerably below the preproject outflow curve. When the adjusted supply indicator is below -15,000 cubic feet per second, the outflow is reduced very rapidly in response to changes in the adjusted supply indicator in order to maintain high levels in anticipation of probable low supply conditions.

Plan 1958-D has two basic rule curves and thus differs from Plan 1958-C which has only one. However, the basic rule curves for the period February to July and for the period August to January above elevation 243.80 are similar to the basic rule curve of Plan 1958-C except that they have been raised 0.03 foot to facilitate computation on IGLD 1955.

V. Seasonal Adjustments

The seasonal adjusted outflows are obtained by adding the seasonal adjustments shown on Column 4 of Table 1 to the outflow derived from the basic rule curve. These seasonal adjustments vary from -20,000 cubic feet per second in the latter part of May and June to +8,000 cubic feet per second in the latter part of November and the early part of December. The purpose of the seasonal adjustments is to store water by a reduction in outflow below the basic rule outflow in the winter, spring and early summer months, and to produce an increase in outflow above the basic rule outflow in the late summer and fall months. This results in a more efficient use of the available storage range and a higher average elevation of Lake Ontario than would be obtained if only the basic rule outflow were used.

The seasonal adjustments have little effect on the water levels of Lake Ontario during high supply periods since the water stored by application of the seasonal adjustments is normally dissipated by December and since from December to July of a high supply period the seasonal adjusted outflows normally exceed the outflows resulting from application of the maximum flow limitations. However, the seasonal adjustments have a beneficial effect on the water levels and outflows of Lake Ontario during low supply

periods by providing high water levels on Lake Ontario at the commencement of such periods.

The seasonal adjustments of Plan 1958-D result in the storage of slightly more water during the spring months and the discharge of slightly more water during the fall months than the seasonal adjustments of Plan 1958-C.

VI. Outflow Limitations

Once the seasonal adjusted outflow has been obtained from the basic rule curve and the seasonal adjustments, it is checked to ensure that it does not violate the various outflow limitations for the period. These outflow limitations are set so that the outflows will not be higher or lower than those necessary to meet the various regulation requirements. The smallest of the maximum outflow limitations and the largest of the minimum outflow limitations set the limits for any period and the seasonal adjusted outflow is used only if it falls below the applicable maximum limitation and above the applicable minimum limitation. The various classifications of outflow limitations are described hereunder.

Channel excavations in the International Rapids Section were designed to provide stipulated limiting depths and velocities for navigation and stipulated maximum velocities for formation of an ice cover. During the period April 1 to December 15, inclusive, outflows are limited by the permissible navigation velocities and depths. As a matter of procedure, the outflow limitation for the April 1 to December 15 period was applied to the December 15 - 31 period also. During January, the regulated outflows are limited by permissible ice-forming velocities. During February and March, the limiting outflows are based on a consideration of winter operating conditions. Those limitations are noted in Column 7 of Figure 4 and are shown on Figure 3 as a function of the water level of Lake Ontario at the end of the preceding period. When these limitations are in effect, they are designated in the computations by the letter (L). The limitations for Plan 1958-D differ from those of Plan 1958-C in that the lower curve of Figure 3 between outflows of 216,000 cubic feet per second and 255,000 cubic feet per second has a slope of 100,000 cubic feet per second per foot, rather than 200,000 cubic feet per second per foot.

During the last half of December, it is necessary at times to reduce the outflows from Lake Ontario so that the outflow from Lake St. Louis will not exceed 280,000 cubic feet per second. The limitation on Lake Ontario outflow for this period is determined by subtracting the inflow between Lake Ontario and Lake St. Louis from 280,000 cubic feet per second, which assumes that the inflow is known

for the current period, and is thus identical with the limitation applied in Plan 1958-C. This outflow limitation is referred to in Column 8 of Figure 4 and is designated by the letter (I) in the computations.

In certain periods of the year it is necessary to have outflow limitations which will control the deviation of the regulated outflows from those outflows which would occur under preproject conditions. The application of these outflow limitations is made relatively easy by the use of the supply indicator. This indicator is approximately equal to the deviation of the preproject outflow from average if ice retardation is neglected. Therefore, an outflow limitation determined by adding this indicator to a fixed quantity for any period, hereinafter referred to as the limiting control number, will bear the same relationship to the preproject outflow that the limiting control number bears to the average preproject outflow for that period. The application of these outflow limitations is automatic since they are obtained by adding the supply indicator at the end of the preceding period to the limiting control number. When the regulated outflow is determined by these limitations, it is denoted in the computations by the letter (P).

The limiting control numbers used to obtain the maximum outflow limitations are tabulated in Column 9 of Figure 4 and are identical to those of Plan 1958-C. It should be noted that these maximum outflow limitations for the period from the 2nd half of April to July, inclusive, are to be used only if the outflow from Lake St. Louis during the preceding quarter exceeds 345,000 cubic feet per second.

The limiting control numbers used to obtain the minimum outflow limitations are tabulated in Column 5 of Figure 4. In application, this limitation is subject to an overriding limit equal to 225,000 cubic feet per second minus 1/6 of the difference between the outflow from Lake St. Louis and the outflow from Lake Ontario for the preceding regulation period. Both the limiting control numbers and the overriding limit differ from those of Plan 1958-C in such a manner as to increase the regulated outflows during the navigation seasonal when the Lake Ontario supplies and Ottawa River flows are low, and to decrease the regulated outflows during the navigation season when the Lake Ontario supplies are low and the Ottawa River flows are high.

The absolute minimum outflows for each period of the year are tabulated in Column 6 of Figure 4. The volume of water available for this purpose is governed by the critically dry periods. The load requirements of the power entities in the International Rapids Section were the chief factor in determining the distribution of the

winter minimum outflows, while the selection of the minimum summer outflows was based on the requirements of the navigation and riparian interests in the Canadian reach of the river. In the computations, this minimum outflow limitation is designated by the letter (M). The minimum outflow limitations of Plan 1958-D are the same as for Plan 1958-C except during the months of July, August and September when they are increased from 190,000 cubic feet per second to 193,000 cubic feet per second.

APPENDIX F

TREATY BETWEEN THE UNITED STATES AND GREAT BRITAIN RELATING TO BOUNDARY WATERS, AND QUESTIONS ARISING BETWEEN THE UNITED STATES AND CANADA

APPENDIX F

TREATY
BETWEEN THE UNITED STATES AND GREAT BRITAIN RELATING TO BOUNDARY WATERS, AND QUESTIONS ARISING BETWEEN THE UNITED STATES AND CANADA.

The United States of America and His Majesty the King of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas, Emperor of India, being equally desirous to prevent disputes regarding the use of boundary waters and to settle all questions which are now pending between the United States and the Dominion of Canada involving the rights, obligations, or interests of either in relation to the other or to the inhabitants of the other, along their common frontier, and to make provision for the adjustment and settlement of all such questions as may hereafter arise, have resolved to conclude a treaty in furtherance of these ends, and for that purpose have appointed as their respective plenipotentiaries:

The President of the United States of America, Elihu Root, Secretary of State of the United States; and

His Britannic Majesty, the Right Honourable James Bryce, O.M., his Ambassador Extraordinary and Plenipotentiary at Washington;

Who, after having communicated to one another their full powers, found in good and due form, have agreed upon the following articles:

PRELIMINARY ARTICLE

For the purposes of this treaty boundary waters are defined as the waters from main shore to main shore of the lakes and rivers and connecting waterways, or the portions thereof, along which the international boundary between the United States and the Dominion of Canada passes, including all bays, arms, and inlets thereof, but not including tributary waters which in their natural channels would flow into such lakes, rivers, and waterways, or waters flowing from such lakes, rivers, and waterways, or the waters of rivers flowing across the boundary.

ARTICLE I

The High Contracting Parties agree that the navigation of all navigable boundary waters shall forever continue free and open for the purposes of commerce to the inhabitants and to the ships, vessels, and boats of both countries equally, subject, however, to any laws and regulations of either country, within its own territory, not inconsistent with such privilege of free navigation and applying equally and without discrimination to the inhabitants, ships, vessels, and boats of both countries.

It is further agreed that so long as this treaty shall remain in force, this same right of navigation shall extend to the waters of Lake Michigan and to all canals connecting boundary waters, and now existing or which may hereafter be constructed on either side of the line. Either of the High Contracting Parties may adopt rules and regulations governing the use of such canals within its own territory and may charge tolls for the use thereof, but all such rules and regulations and all tolls charged shall apply alike to the subjects or citizens of the High Contracting Parties and the ships, vessels, and boats of both of the High Contracting Parties, and they shall be placed on terms of equality in the use thereof.

ARTICLE II

Each of the High Contracting Parties reserves to itself or to the several State Governments on the one side and the Dominion or Provincial Governments on the other as the case may be, subject to any treaty provisions now existing with respect thereto, the exclusive jurisdiction and control over the use and diversion, whether temporary or permanent, of all waters on its own side of the line which in their natural channels would flow across the boundary or into boundary waters; but it is agreed that any interference with or diversion from their natural channel of such waters on either side of the boundary, resulting in any injury on the other side of the boundary, shall give rise to the same rights and entitle the injured parties to the same legal remedies as if such injury took place in the country where such diversion or interference occurs; but this provision shall not apply to cases already existing or to cases expressly covered by special agreement between the parties hereto.

It is understood, however, that neither of the High Contracting Parties intends by the foregoing provision to surrender any right, which it may have, to object to any interference with or diversions of waters on the other side of the boundary the effect of which would be productive of material injury to the navigation interests on its own side of the boundary.

ARTICLE III

It is agreed that, in addition to the uses, obstructions, and diversions heretofore permitted or hereafter provided for by special argreement between the Parties hereto, no further or other uses or obstructions or diversions, whether temporary or permanent, of boundary waters on either side of the line, affecting the natural level or flow of boundary waters on the other side of the line shall be made except by authority of the United States or the Dominion of Canada within their respective jurisdictions and with the approval, as hereinafter provided, of a joint commission, to be known as the International Joint Commission.

The foregoing provisions are not intended to limit or interfere with the existing rights of the Government of the United States on the one side and the Government of the Dominion of Canada on the other, to undertake and carry on governmental works in boundary waters for the deepening of channels, the construction of breakwaters, the improvement of harbours, and other governmental works for the benefit of commerce and navigation, provided that such works are wholly on its own side of the line and do not materially affect the level or flow of the boundary waters on the other, nor are such provisions intended to interfere with the ordinary use of such waters for domestic and sanitary purposes.

ARTICLE IV

The High Contracting Parties agree that, except in cases provided for by special agreement between them, they will not permit the construction or maintenance on their respective sides of the boundary of any remedial or protective works or any dams or other obstructions in waters flowing from boundary waters or in waters at a lower level than the boundary in rivers flowing across the boundary, the effect of which is to raise the natural level of waters on the other side of the boundary unless the construction or maintenance thereof is approved by the aforesaid International Joint Commission.

It is further agreed that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other.

ARTICLE V

The High Contracting Parties agree that it is expedient to limit the diversion of waters from the Niagara River so that the level of Lake Erie and the flow of the stream shall not be appreciably affected. It is the desire of both Parties to accomplish this object with the least possible injury to investments which have already been made in the construction of power plants on the United States side of the river under grants of authority from the State of New York, and on the Canadian side of the river under licences authorized by the Dominion of Canada and the Province of Ontario.

So long as this treaty shall remain in force, no diversion of the waters of the Niagara River above the Falls from the natural course and stream thereof shall be permitted except for the purposes and to the extent hereinafter provided.

The United States may authorize and permit the diversion within the State of New York of the waters of said river above the Falls of Niagara, for power purposes, not exceeding in the aggregate a daily diversion at the rate of twenty thousand cubic feet of water per second.

The United Kingdom, by the Dominion of Canada, or the Province of Ontario, may authorize and permit the diversion within the Province of Ontario of the waters of said river above the Falls of Niagara, for power purposes, not exceeding in the aggregate a daily diversion at the rate of thirty-six thousand cubic feet of water per second.

The prohibitions of this article shall not apply to the diversion of water for sanitary or domestic purposes, or for the service of canals for the purposes of navigation.

NOTE: The third, fourth and fifth paragraphs of Article V were terminated by the Canada-United States Treaty of February 27, 1950 concerning the diversion of the Niagara River.

ARTICLE VI

The High Contracting Parties agree that the St. Mary and Milk Rivers and their tributaries (in the State of Montana and the Provinces of Alberta and Saskatchewan) are to be treated as one stream for the purposes of irrigation and power, and the waters thereof shall be apportioned equally between the two countries, but in making such equal apportionment more than half may be taken from one river and less than half from the other by either country so as to afford a more beneficial use to each. It is further agreed that in the division of such waters during the irrigation season, between the 1st of April and 31st of October, inclusive, annually, the United States is entitled to a prior appropriation of 500 cubic feet per second of the waters of the Milk River, or so much of such amount as constitutes three-fourths of its natural flow, and that Canada is entitled to a prior appropriation of 500 cubic feet per second of the flow of St. Mary River, or so much of such amount as constitutes three-fourths of its natural flow.

The channel of the Milk River in Canada may be used at the convenience of the United States for the conveyance, while passing through Canadian territory, of waters diverted from the St. Mary River. The provisions of Article II of this treaty shall apply to any injury resulting to property in Canada from the conveyance of such waters through the Milk River.

The measurement and apportionment of the water to be used by each country shall from time to time be made jointly by the properly constituted reclamation officers of the United States and the properly constituted irrigation officers of His Majesty under the direction of the International Joint Commission.

ARTICLE VII

The High Contracting Parties agree to establish and maintain an International Joint Commission of the United States and Canada composed of six commissioners, three on the part of the United States appointed by the President thereof, and three on the part of the United Kingdom appointed by His Majesty on the recommendation of the Governor in Council of the Dominion of Canada.

ARTICLE VIII

This International Joint Commission shall have jurisdiction over and shall pass upon all cases involving the use or obstruction or diversion of the waters with respect to which under Articles III and IV of this Treaty the approval of this Commission is required, and in passing upon such cases the Commission shall be governed by the following rules or principles which are adopted by the High Contracting Parties for this purpose:

The High Contracting Parties shall have, each on its own side of the boundary, equal and similar rights in the use of the waters hereinbefore defined as boundary waters.

The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:

(1) Uses for domestic and sanitary purposes;

(2) Uses for navigation, including the service of canals for the purposes of navigation;

(3) Uses for power and for irrigation purposes.

The foregoing provisions shall not apply to or disturb any existing uses of boundary waters on either side of the boundary.

The requirement for an equal division may in the discretion of the Commission be suspended in cases of temporary diversions along boundary waters at points where such equal division can not be made advantageously on account of local conditions, and where such diversion does not diminish elsewhere the amount available for use on the other side.

The Commission in its discretion may make its approval in any case conditional upon the construction of remedial or protective works to compensate so far as possible for the particular use or diversion proposed, and in such cases may require that suitable and adequate provision, approved by the Commission, be made for the protection and indemnity against injury of any interests on either side of the boundary.

In cases involving the elevation of the natural level of waters on either side of the line as a result of the construction or maintenance on the other side of remedial or protective works or dams or other obstructions in boundary waters or in waters flowing therefrom or in waters below the boundary in rivers flowing across the boundary, the Commission shall require, as a condition of its approval thereof, that suitable and adequate provision, approved by it, be made for the protection and indemnity of all interests on the other side of the line which may be injured thereby.

The majority of the Commissioners shall have power to render a decision. In case the Commission is evenly divided upon any question or matter presented to it for decision, separate reports shall be made by the Commissioners on each side to their own Government. The High Contracting Parties shall thereupon endeavour to agree upon an adjustment of the question or matter of difference, and if an agreement is reached between them, it shall be reduced

to writing in the form of a protocol, and shall be communicated to the Commissioners, who shall take such further proceedings as may be necessary to carry out such agreement.

ARTICLE IX

The High Contracting Parties further agree that any other questions or matters of difference arising between them involving the rights, obligations, or interests of either in relation to the other or to the inhabitants of the other, along the common frontier between the United States and the Dominion of Canada, shall be referred from time to time to the International Joint Commission for examination and report, whenever either the Government of the United States or the Government of the Dominion of Canada shall request that such questions or matters of difference be so referred.

The International Joint Commission is authorized in each case so referred to examine into and report upon the facts and circumstances of the particular questions and matters referred, together with such conclusions and recommendations as may be appropriate, subject, however, to any restrictions or exceptions which may be imposed with respect thereto by the terms of the reference.

Such reports of the Commission shall not be regarded as decisions of the questions or matters so submitted either on the facts or the law, and shall in no way have the character of an arbitral award.

The Commission shall make a joint report to both Governments in all cases in which all or a majority of the Commissioners agree, and in case of disagreement the minority may make a joint report to both Governments, or separate reports to their respective Governments.

In case the Commission is evenly divided upon any question or matter referred to it for report, separate reports shall be made by the Commissioners on each side to their own Government.

ARTICLE X

Any questions or matters of difference arising between the High Contracting Parties involving the rights, obligations, or interests of the United States or of the Dominion of Canada either in relation to each other or to their respective inhabitants, may be referred for decision to the International Joint Commission by the consent of the two Parties, it being understood that on the part of the United States any such action will be by and with the advice and consent of the Senate, and on the part of His Majesty's Government with the consent of the Governor General in Council. In each case so referred, the said Commission is authorized to examine into and report upon the facts and circumstances of the particular questions and matters referred, together with such conclusions and recommendations as may be appropriate, subject, however, to any restrictions or exceptions which may be imposed with respect thereto by the terms of the reference.

A majority of the said Commission shall have power to render a decision or finding upon any of the questions or matters so referred.

If the said Commission is equally divided or otherwise unable to render a decision or finding as to any questions or matters so referred, it shall be the duty of the Commissioners to make a joint report to both Governments, or separate reports to their respective Governments, showing the different conclusions arrived at with regard to the matters or questions so referred, which questions or matters shall thereupon be referred for decision by the High Contracting Parties to an umpire chosen in accordance with the procedure prescribed in the fourth, fifth and sixth paragraphs of Article XLV of the Hague Convention for the pacific settlement of international disputes, dated

October 18, 1907. Such umpire shall have power to render a final decision with respect to those matters and questions so referred on which the Commission failed to agree.

ARTICLE XI

A duplicate original of all decisions rendered and joint reports made by the Commission shall be transmitted to and filed with the Secretary of State of the United States and the Governor General of the Dominion of Canada, and to them shall be addressed all communications of the Commission.

ARTICLE XII

The International Joint Commission shal meet and organize at Washington promptly after the members thereof are appointed, and when organized the Commission may fix such times and places for its meetings as may be necessary, subject at all times to special call or direction by the two Governments. Each Commissioner upon the first joint meeting of the Commission after his appointment, shall, before proceeding with the work of the Commission, make and subscribe a solemn declaration in writing that he will faithfully and impartially perform the duties imposed upon him under this treaty, and such declaration shall be entered on the records of the proceedings of the Commission.

The United States and Canadian sections of the Commission may each appoint a secretary, and these shall act as joint secretaries of the Commission at its joint sessions, and the Commission may employ engineers and clerical assistants from time to time as it may deem advisable. The salaries and personal expenses of the Commission and of the secretaries shall be paid by their respective Governments, and all reasonable and necessary joint expenses of the Commission, incurred by it, shall be paid in equal moieties by the High Contracting Parties.

The Commission shall have power to administer oaths to witnesses, and to take evidence on oath whenever deemed necessary in any proceeding, or inquiry, or matter within its jurisdiction under this treaty, and all parties interested therein shall be given convenient oportunity to be heard, and the High Contracting Parties agree to adopt such legislation as may be appropriate and necessary to give the Commission the powers above mentioned on each side of the boundary, and to provide for the issue of subpœnas and for compelling the attendance of witnesses in procedings before the Commission. The Commission may adopt such rules of procedure as shall be in accordance with justice and equity, and may make such examination in person and through agents or employees as may be deemed advisable.

ARTICLE XIII

In all cases where special agreements between the High Contracting Parties hereto are referred to in the foregoing articles, such agreements are understood and intended to include not only direct agreements between the High Contracting Parties, but also any mutual arrangement between the United States and the Dominion of Canada expressed by concurrent or reciprocal legislation on the part of Congress and the Parliament of the Dominion.

ARTICLE XIV

The present treaty shall be ratified by the President of the United States of America, by and with the advice and consent of the Senate thereof, and by His Britannic Majesty. The ratifications shall be exchanged at Washington as soon as possible and the treaty shall take effect on the date of the exchange

of its ratifications. It shall remain in force for five years, dating from the day of exchange of ratifications, and thereafter until terminated by twelve months' written notice given by either High Contracting Party to the other.

In faith whereof the respective plenipotentiaries have signed this treaty in duplicate and have hereunto affixed their seals.

Done at Washington the 11th day of January, in the year of our Lord one thousand nine hundred and nine.

(Signed) ELIHU ROOT [SEAL]

(Signed) JAMES BRYCE [SEAL]

AND WHEREAS the Senate of the United States by their resolution of March 3, 1909, (two-thirds of the Senators present concurring therein) did advise and consent to the ratification of the said Treaty with the following understanding, to wit:

"Resolved further, as a part of this ratification, That the United States approves this treaty with the understanding that nothing in this treaty shall be construed as affecting, or changing, any existing territorial or riparian rights in the water, or rights of the owners of lands under water, on either side of the international boundary at the rapids of the St. Mary's river at Sault Ste. Marie, in the use of the waters flowing over such lands, subject to the requirements of navigation in boundary waters and of navigation canals, and without prejudice to the existing right of the United States and Canada, each to use the waters of the St. Mary's river, within its own territory, and further, that nothing in this treaty shall be construed to interfere with the drainage of wet swamp and overflowed lands into streams flowing into boundary waters, and that this interpretation will be mentioned in the ratification of this treaty as conveying the true meaning of the treaty, and will, in effect, form part of the treaty;"

AND WHEREAS the said understanding has been accepted by the Government of Great Britain, and the ratifications of the two Governments of the said treaty were exchanged in the City of Washington, on the 5th day of May, one thousand nine hundred and ten;

NOW, THEREFORE, be it known that I, William Howard Taft, President of the United States of America, have caused the said treaty and the said understanding, as forming a part thereof, to be made public, to the end that the same and every article and clause thereof may be observed and fulfilled with good faith by the United States and the citizens thereof.

In testimony whereof, I have hereunto set my hand and caused the seal of the United States to be affixed.

Done at the City of Washington this thirteenth day of May in the year of our Lord one thousand nine hundred and ten,
[SEAL] and of the Independence of the United States of America the one hundred and thirty-fourth.

Wm H Taft

By the President:

P C Knox
Secretary of State.

PROTOCOL OF EXCHANGE.

On proceeding to the exchange of the ratifications of the treaty signed at Washington on January 11, 1909, between the United States and Great Britain, relating to boundary waters and questions arising along the boundary between the United States and the Dominion of Canada, the undersigned plenipotentiaries, duly authorized thereto by their respective Governments, hereby declare that nothing in this treaty shall be construed as affecting, or changing, any existing territorial, or riparian rights in the water, or rights of the owners of lands under water, on either side of the international boundary at the rapids of the St. Mary's River at Sault Ste. Marie, in the use of the waters flowing over such lands, subject to the requirements of navigation in boundary waters and of navigation canals, and without prejudice to the existing right of the United States and Canada, each to use the waters of the St. Mary's River, within its own territory; and further, that nothing in this treaty shall be construed to interfere with the drainage of wet, swamp, and overflowed lands into streams flowing into boundary waters, and also that this declaration shall be deemed to have equal force and effect as the treaty itself and to form an integral part thereto.

The exchange of ratifications then took place in the usual form.

In witness whereof, they have signed the present Protocol of Exchange and have affixed their seals thereto.

DONE at Washington this 5th day of May, one thousand nine hundred and ten.

PHILANDER C KNOX [SEAL]

JAMES BRYCE [SEAL]

APPENDIX G

ORGANIZATIONS AND MEMBERS

APPENDIX G

Organizations and Members

Following are listings of the members and mailing address of the organizations dealing with control of the water level of Lake Ontario.

INTERNATIONAL JOINT COMMISSION

UNITED STATES SECTION*

Honorable Christian A. Herter, Jr., Chairman

Honorable Charles R. Ross, Commissioner

Honorable Victor L. Smith, Commissioner

William A. Bullard, Secretary
John F. Hendrickson, Executive Director
Stewart H. Fonda, Jr., Engineer Adviser
James G. Chandler, Attorney Adviser

Suite 203, 1717 H Street, N. W., Washington,
D. C. 20440 STOP NO. 86
Phone 202-296-2142

CANADIAN SECTION*

Honorable Maxwell Cohen, Chairman

Honorable Bernard Beaupre, Commissioner

Honorable Keith A. Henry, Commissioner

David G. Chance, Secretary
J. Lloyd MacCallum, Legal Adviser and Assistant to the Chairman
Murray W. Thompson, Engineer Adviser

Suite 850, 151 Slater Street, Ottawa, Ontario
K1P 5H3
Phone 613-992-2945

*Membership as of 19 Sept. 1974

INTERNATIONAL GREAT LAKES LEVELS BOARD

BOARD MEMBERS*

UNITED STATES

**BG W. O. BACHUS
Division Engineer
North Central
Corps of Engineers
536 South Clark Street
Chicago, Illinois 60605

Mr. B. T. JOSE
St. Lawrence Seaway
Development Corp.
(retired)
21 Sherwood Drive
Massena, New York 13662

Mr. MARK ABELSON
Staff Assistant, Office
of the Secretary
U. S. Department of the
Interior
450 Golden Gate Avenue
San Francisco, California
94102

CANADA

**Mr. C. K. HURST
Director of Engineering
Department of Public Works
Sir Charles Tupper Building
Ottawa, Ontario K1A 0M2

Mr. R. H. SMITH
Chief, Waterways Development
Division
Ministry of Transport
Place de Ville - 300 Sparks St.
Ottawa, Ontario K1A ON5

Mr. N. H. JAMES
Director, Water Planning and
Management Branch
Inland Waters Directorate
Department of the Environment
Ottawa, Ontario K1A OE7

* Membership as of 26 Sept. 1974
** Chairman

INTERNATIONAL ST. LAWRENCE RIVER BOARD OF CONTROL

BOARD MEMBERS*

UNITED STATES

**BG W. O. BACHUS
Division Engineer
North Central
Corps of Engineers
536 South Clark Street
Chicago, Illinois 60605

Mr. D. BROWN
Head, Section of Inspections
Bureau of Power
Federal Power Commission
Washington, D. C. 20426

Mr. R. D. CONNER
Resident Manager
Power Authority of the State of New York
P.O. Box 110
Massena, New York 13662

CANADA

**Mr. R. H. SMITH
Chief, Waterways Development Division
Ministry of Transport
Place de Ville - 300 Sparks St.
Ottawa, Ontario K1A ON5

Mr. J. B. BRYCE
Hydraulic Engineer
Generation Dept.
Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario, Canada

Mr. R. H. CLARK
Engineering Adviser
Inland Waters Directorate
Department of Environment
870 Carling Avenue
Ottawa 1, Ontario, Canada

Mr. Y. DeGUISE
Commissioner
Hydro-Electric Power Commission of Quebec
75 Dorchester Blvd., West
Montreal, P.Q., Canada

*Membership as of 26 Sept. 1974
**Chairman

REGULATION REPRESENTATIVES*

UNITED STATES	CANADA
COLONEL BERNARD HUGHES U.S. Army Corps of Engineers Buffalo District 1776 Niagara Street Buffalo, New York 14207	Mr. DAVID WITHERSPOON Engineer-in-Charge Great Lakes-St. Lawrence Study Office Environment Canada 318 Federal Building Cornwall, Ontario, Canada K6H 5R8

*Representation as of December 4, 1974

OPERATIONS ADVISORY GROUP MEMBERS*

UNITED STATES

Mr. JOHN ADAMS
St. Lawrence Seaway
Development Corporation
Massena, New York 13662

Mr. JOHN BARTHOLOMEW
Power Authority of the State
of New York
Massena, New York 13662

CANADA

Mr. THOMAS WEGLE
Hydro-Electric Power
Commission of Ontario
Toronto, Ontario, Canada

Mr. FERDNARD SANTARE
Hydro-Electric Power
Commission of Quebec
Montreal, P.Q., Canada

Mr. CHARLES LAWRIE
Ministry of Transport
Ottawa, Ontario

*Membership as of December 12, 1974

ADDENDUM 1

DISCUSSION OF REVIEWERS COMMENTS

ADDENDUM 1

Discussion of Reviewers Comments

Draft copies of this document were forwarded to 52 individuals for technical review. In general, the comments received indicated four areas of weakness existed in the draft report. Briefly they were as follows:

1. Insufficient credit was given to the beneficial effects of the current regulation plan. In order to remedy this shortcoming a section was added, including Figure 29 which reflects preproject and actual lake levels since 1960, discussing the positive benefits from the current regulation plan.

2. Insufficient background into the basis of lake regulation was provided. In order to provide this background two appendicies, E and F, were added. These provide the text of the Treaty of 1909 and the Office Consolidation of the Order of Approval upon which the Plan of Regulation is based.

3. It was felt the report was over critical of the actions of the members of the St. Lawrence River Board of Control. To clarify the Commission's position the text was reworded, as required, to indicate that it is not the Board members but the institutional framework that limits their management options that is being questioned by this report. Also as explained in Footnote 11 Chapter VI the criticism rendered is not a personal attack on the Board members.

4. The discussion of lake level forecasting was felt to be inadequate. This section was rewritten and expanded to include discussion of the methods of forecasting currently used.

Included in this Addendum are the letters received from the reviewers. Each comment was examined and a decision rendered whether to revise the text of the report or not. To aid the reader of this report the following format was utilized in this Addendum. The review comment is printed as received followed by a summary of the action taken by the Commission in revising the text. This summary is typed in italic type and enclosed in brackets [ ]. Although the letters from the reviewers are segmented they do appear in their entirety.

STATE OF NEW YORK
DIVISION OF MILITARY AND NAVAL AFFAIRS
PUBLIC SECURITY BUILDING
STATE CAMPUS
ALBANY, NEW YORK 12226

MALCOLM WILSON
GOVERNOR
COMMANDER IN CHIEF

JOHN C. BAKER
MAJOR GENERAL
CHIEF OF STAFF TO THE GOVERNOR

MNDP

23 December 1974

Mr. William E. Tyson, Executive Director
St. Lawrence-Eastern Ontario Commission
317 Washington Street
Watertown, New York 13601

Dear Mr. Tyson:

The following comments are submitted following a review of the draft transmitted with your letter of 18 December 1974.

1. Page 3 - First paragraph

   a. The March 1973 storm resulted in a Presidential declaration of major disaster. The term, major disaster, is the legal phrase under Public Law 91-606.
   b. The Federal-State Disaster Assistance Agreement states, "On March 21, 1973, the President determined that damages resulting from high winds, wave action, and flooding beginning on or about March 16, 1973, have caused a major disaster ... The duration of the catastrophe, causing the damage with which this Agreement is concerned, was from the 16th day of March, 1973, through the 23rd day of March, 1973 ..."

   [*The text was revised to incorporate the correct terminology.*]

2. Page 109 to Page 115

   a. It is important to be clear when one speaks of disasters. Under Federal legislation in effect in 1973, the declaration by the President of a major disaster, as occurred on 21 March 1973, included the triggering of disaster loan action by the Small Business Administration. Had the major disaster not been declared, it might have been necessary to obtain a disaster declaration from the Small Business Administrator, which would

have made available the SBA disaster loans, but not other forms of Federal aid. I suggest you check with SBA to ascertain whether their loans were made under the major disaster OEP 367-DR, or under the SBA's disaster authority, or both.

[*Mr. Howard Garity, Office Manager, Elmira Office, SBA indicated that the Federal declaration was utilized to make loans available. The text was revised to reflect this point.*]

b. With respect to the table on pages 114 and 115:

(1) Date the table. Suggest it be dated as of 20 December 1974.

(2) Correct spelling of Town of Sodus, Wayne County.

(3) On page 115, make the following dollar changes:

(a) Village of Alexandria Bay - change from $6,250 to $8,480.

(b) Jefferson County total - change from $193,267 to $195,497.

(c) Total - change from $1,127,958 to $1,130,188.

[*The table was updated and the changes suggested were incorporated.*]

Although this agency's primary concern is coordinating the furnishing of disaster assistance after the fact, and my comments about the draft have been limited to that concern, I endorse heartily the recommendations relative to pre-disaster actions which could reduce the danger of losses, such as land use management and implementation of the flood insurance program. I am also personally in sympathy with Recommendations 4-1 and 4-2 on pages 16 and 17, Recommendation 8-1 on page 18, Recommendation 1-1 on page 19, and Recommendation 2-1, 2-2, and 2-3 on page 20.

Sincerely,

ARNOLD W. GRUSHKY
Deputy Director of Civil Defense

egp

RHS/lw

Transport Canada / Transports Canada

Marine / Marine

Your file / Votre référence

Our file / Notre référence

8 January 1975

Mr W.E. Tyson
Executive Director
St. Lawrence-Eastern Ontario Commission
317 Washington Street
Watertown
New York, 13601.

Dear Mr Tyson,

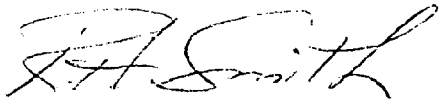
Thank you very much for providing me with a copy of the December 1974 draft report of your Commission concerning the water levels on Lake Ontario at the St. Lawrence River. The review of it, which I have made, indicates to me that a great deal of research has gone into this matter on behalf of your Commission.

With respect to specific comments, it is my understanding that these are being assembled on behalf of many of us involved at the Federal Government level by the International Joint Commission. Consequently, I have discussed what I consider to be certain gaps in the report with the Chief Engineer of the Canadian Section, IJC. These included the absence of any detailed reference to the IJC's Orders of Approval for the St. Lawrence Project and the background related thereto, and the lack of emphasis on the results of the water level control of Lake Ontario compared with the conditions that would have resulted without such control (i.e. preproject).

[*Appendices D and F were added to the report. They provide the text of the Treaty of 1909 and the Office Consolidation of the Order of Approval. In addition the text was expanded to discuss the benefits resulting from the current regulation plan.*]

I would appreciate being sent a copy of your report once it has been finalized.

Yours sincerely,



R.H. Smith
Chief
Waterways Development

Your file Votre dossier

Our file Notre dossier

Environment Canada / Environnement Canada

Water Management / Gestion des Eaux

318 Federal Building,
Cornwall, Ontario, K6H 5R8,
9 January, 1975.

William E. Tyson, Esq.,
Executive Director,
St. Lawrence-Eastern Ontario
Commission,
317 Washington St.,
Watertown, N.Y., 13601.

Dear Mr. Tyson:

Thank you for the opportunity to comment on the report on the "Analysis of and Recommendations Concerning High Water Levels on Lake Ontario and the St. Lawrence River" by the St. Lawrence-Eastern Ontario Commission. My detailed comments are attached. By way of summary, it is apparent from the report that the author has several basic misunderstandings. Although he describes briefly and clearly the problems related to the regulation of lake levels on pages 127 and 128, he fails to appreciate that the most important single factor in the amount of control of Lake Ontario levels which can be achieved is the hydraulic capacity of the St. Lawrence River in the winter months. This description (pages 127 and 128) and the above fact are inconsistent with the findings which attach the fault for high lake levels to the institutional arrangements and the implication that regulation decisions are based on lack of knowledge. This implication is incorrect and can only lead to public misunderstanding.

The text was expanded to discuss the limitations of the current hydraulic capacity of the St. Lawrence River. However, as addressed by the report the question of whether or not the adverse impacts were minimized through the implementation of flood damage reduction techniques still remains at issue.

Further, before your commission, by its report, criticizes the international institutions and how they operate, their basis and their intended purpose agreed to by both the governments of Canada and the United States should be thoroughly understood. Misunderstanding of these institutional arrangements is exhibited in your report since the basic documents governing the operation of the International Rapids Section of the St. Lawrence River are ignored. These documents are the Order of Approval of the International Joint Commission for the St. Lawrence Power Project in the International Rapids Section of the St. Lawrence River dated 29 October, 1952 and the Supplementary Order of Approval dated 2 July, 1956.

Page 141-142 and 151 of the draft text discuss the Order of Approval and the Treaty of 1909. In the final report Appendices D and F were added which provide the text of the Treaty of 1909

and the Office Consolidation of the Order of Approval. The question being addressed by the report is whether the criteria as set forth are now relevant due to the passage of time and the high water levels recently experienced. Only a complete re-evaluation, as called for in the report, can answer this question. The text was expanded to include a discussion of the benefits derived from the current plan of regulation. Page 155 of the draft stated that the Plan of Control as implemented reflected a degree of flexibility, discretionary powers in your words.

The approved regulation plan (Plan 1958-D) is the plan of operation which attempts to meet the requirements of these orders. In addition, the International St. Lawrence River Board of Control has discretionary powers to deviate from this plan under certain circumstances. It is important that a full understanding of these arrangements be conveyed in your report or unfortunate public misconceptions may develop.

If you require further explanation of these comments, please contact my office at the above address or phone 613-932-4325.

Yours sincerely,

D. F. Witherspoon
Engineer-in-Charge
Great Lakes-St. Lawrence
Study Office

Encl.

Comments of D. F. Witherspoon
on
"Analysis of and Recommendations Concerning
High Water Levels on Lake Ontario and the St. Lawrence River"
by
St. Lawrence-Eastern Ontario Commission

P.1 Para. 2 -

Basic premise incorrect - man's ability to control is limited by the physical system. If absolute control of levels desired then St. Lawrence would require capacity equivalent to greatest water supply which might occur or a channel capacity equivalent to two St. Lawrence Rivers.

[*It is contended that controls or control of the lake levels is limited by technology and institutional constraints. The latter can be reflected by the fact that the navigation channel depth was set at 27 feet or the fact that imposed economic criteria require a B/C greater than one. Physical constraints are removable if technology exists and economics show it to be feasible. Example - the International Rapids section of the St. Lawrence was at one time a physical constraint to shipping but as it became technologically and economically feasible to remove it efforts were undertaken to partially do so.*]

P.5 Para. 3 -

Lake Ontario experienced a mean daily level of 246.75 on 16 July 1972, the highest level for the year. The range within which it is to be regulated is 242.77 to 246.77 are monthly mean levels. July monthly mean in 1972 was 246.68.

The maximum allowable outflow under Plan 1958-D is 310,000 cfs. It is incorrect to say it is specified for navigation requirement - it is not above any limitation, it is the maximum outflow limitation of Plan 1958-D.

Lowest mean daily level 244.50 - 6 November 1972

Lowest monthly level 244.58 ~ November 1972

Long term mean (normal) for November - 243.99

[*In order to clarify the lake levels information the text was expanded to include this.*]

P.6 -

To convey a correct picture, the level of Lake Ontario without control should also be given - October 1972, 246.52.

[*Figure 29 was added to reflect water levels with and without the project in order that water levels under the two conditions could be compared.*]

P.7 Para. 2 L.4 -

"335,000 cfs in the first week of August"
should read
"350,000 cfs in the first week of June"

[*The change in flow data was made.*]

P.7 Para. 4 -

Some of the weakness of the ice cover in 1972-73 can be attributed to the high flow being passed under it.

[*No comment.*]

P. 8 Para. 2 -

"351,000 cfs" should read 350,000 cfs - a monthly mean.

[*The mean daily flow is being referenced here. In order to clarify this it was identified as such.*]

P. 8 Para. 4 -

A lower level has been achieved in 1974 of 244.00 in November - normal 243.99 - low 1973 level 244.33 in December.

[*No comment.*]

P.9 Para. 1 -

Navigation had similar problems in fall 1974 as in 1973.

The level of Montreal Harbour through the summer and fall months of these years (1973-74) did not influence the decision on the amount of water released from Lake Ontario. The principal factor is the depth for navigation in the project area i.e. Ogdensburg to Massena and reduction of the time flooding occurs downstream on Lake St. Louis.

[*A member of the St. Lawrence River Board of Control provided the commentary in the draft text.*]

P.9 Para. 2 - 2nd sentence -

Power interests receive very little additional benefit from high discharges beyond their maximum efficiency, about 270,000 cfs and some adverse impact due to lower head.

[*Discussion with the resident manager of Moses Dam indicated that the net value of flows above 270,000 cfs was positive until the full capacity of the facility is reached at 325,000 cfs.*]

P.9 Para. 3 -

The greatest drawdown of Lake St. Lawrence in 1974 occurred at flows less than 310,000 cfs.

[*The periods when flows were less than 310,000 cfs in 1974 were: Jan 1-Mar 20 - 205,000-310,000; Apr 6-Apr 12 - 308,000; May 20-27 - 305,000-300,000; Sept 23 - 309,000; Oct 2 - 309,000; Oct 12-Dec 31 - 309,000-270,000*

Drawdowns at this time of the year are less objectional than during periods when water contact recreation takes place.]

P.10 Para. 2 -

Conflicts also arise when below normal water supplies occur i.e. 1964.

[*Study period was years of high water levels.*]

The current regulation plan 1958-D has been in effect since 4 October 1963.

[*Pages 142-145 of draft cover this.*]

The agreed upon goal of the Board over the past three years has been to utilize the capacity of the river to its maximum without excluding the use of the river by any interest. The 3rd sentence in paragraph 2 misrepresents the facts and is the sort of innuendo which leads to a badly informed public.

[*The goal of the Board is one of the key issues being addressed by this report. The Commission feels it should be the minimization of adverse impacts.*]

The 3rd sentence misrepresents the Board and demonstrates a total misunderstanding of the International Joint Commission's intent in choosing membership on the Board. The intent is that Board members are chosen for their expertise in relation to the technical questions involved, not because they represent an interest!

[*The Commission feels that at least one resident in the drainage basin of the St. Lawrence River-Lake Ontario not associated with government, power, or navigation has the required expertise to deal with the problems of lake level regulation.*]

When the levels are high, a flow of between 270,000 cfs and 310,000 cfs is a desirable flow.

[*Desirable for who-riparian owners, power interest or navigation interest? As discussed in the text there is conflict between these groups and the 270,000 to 310,000 cfs flow is not desirable for all three groups.*]

If the innuendo of this paragraph were carried out, Lake St. Lawrence would be dry. Would this be in the riparian interest? Montreal would be in a flood condition for six months a year - is this in the riparian interest?

[*The Commission fails to arrive at the same conclusion. At issue is the question of whether the current implementation of the Plan, or the design of the Plan, allows the minimization of damages to occur.*]

The last sentence of this paragraph is incorrect. If there is a conflict

it is between upstream and downstream riparians. Power interests have never objected to any outflow during 1973-74. Navigation require certain depths in the fall or they would be excluded from the use of the river. As a result of the choice of flows during the fall in 1972, 1973 and 1974 navigation have suffered losses due to delay since the river was at its minimum profile and wind effects decrease depths at times stopping navigation.

The qualifying statement "during periods of high water" was added to the text. The problem of upstream and downstream riparian conflict is addressed throughout the text and is recognized by the division of riparian owners into two groups-above and below the control structures. The correctness of the sentence stands as qualified. The outflow desired during periods of high water by riparian owners above the control structures differs from that desired by power and navigation. The majority of the former desire releases as great as possible, the latter, as you stated in your comments would like to manage the flow to insure adequate flow in the fall.

Pages 99-109 documents the impacts to navigation.

P.10 last Para. and top P.11 -

It is most impractical to talk of stage damage curves because it is doubtful that either of our countries would permit damage to be caused in Canada to prevent damage in the United States. The only practical discussion which can take place is with reference to preproject or natural conditions i.e. if the project had not been constructed.

The Commission feels that the "practical" way you see it is not the only way. We advocate throughout the report a different approach. Precedent has been set through the enactment of the Columbia River Treaty.

P.11 -

Economics are not the final argument. Two nations are involved in the operation.

The Commission simply asks "Is not the objective of the two nations to maximize the benefits from usage of the river and lakes?"

P.11 last Para.

Statement is inaccurate - see comments with reference to page 10. This is to say the governments of Canada and the United States are biased. The Board's representative in Canada is specifically charged to look at interests in Canada. All of the decisions made are made considering the technical consequences i.e. how to lower levels of Lake Ontario and not flood Lake St. Louis while providing adequate depth for navigation.

The thoughts of the Commission were clarified by the revision of the text in this section and the addition of a footnote.

All the necessary knowledge is available as to the effects of specific flow on such a decision.

[*As discussed throughout the text the Commission feels that adequate data is not available upon which to base management decisions.*]

Statements such as this paragraph are innuendo and in themselves based on in adequate knowledge.

[*(see preceeding statement)*]

P.12 Para. 2, 3 and 4 -

When international problems are to be solved, economics are not the answer. The relationship to natural conditions have always been used to date on the St. Lawrence and Lake Ontario - see comment for P.10 last paragraph.

[*This is one of the questions at issue. Is this the appropriate basis for the establishment of a decision criteria.*]

P.13 Para. 1 -

It must be emphasized the protection of the various interests in already written into the Orders of the International Joint Commission. The persons advising and making the decisions must recognize these orders as well as the technical considerations in the regulation of Lake Ontario and the St. Lawrence River. To further imply that the regulation has not been impartial is to impune the motives of professional engineers in both countries responsible for the advice provided to the Board and the International Joint Commission.

[*As the revised text clarifies it is not the Board members themselves that are being criticized but the institutional constraints which limit their management options. However, it remains that the institutional arrangements are biased against riparian owners. Also, since the Order of Approval requires the Board to make recommendations concerning the Plan of Control it seems as if their current effort should be expanded to include a reevaluation of the criteria.*]

To make a statement such as paragraph 1 is the worst kind of innuendo since it is made without knowledge of the technical considerations behind the decisions made. The simple fact remains - the St. Lawrence River has not the capacity to discharge the waters required to keep Lake Ontario below an arbitrary elevation of 246.77 at all times. Without recognition of this fact even the best "Monday morning quarterbacking" is to no avail.

[*The Commission, as stated throughout the text, feels that the degree of flexibility existing does not permit effective water level regulation.*]

P.13 Para. 3 -

There is considerable flexibility in existing international arrangements.

[*No comment.*]

P.15 Recommendation 2-1 -

The International St. Lawrence River Board of Control has never been an adversary proceeding. It is a group of engineers who come to a technical decision. If there is a conflict, it is decided by the International Joint Commission. The members are nominated by their respective jurisdictions, Government of Canada, Provinces of Ontario and Quebec. The State of New York has a nominated member on the U. S. Section of the Board.

Finding 3 - incorrect. Flooding on Lake St. Louis occurs when the outflow from that lake exceeds about 380,000 cfs including the contribution from the Ottawa. A knowledge of the geography of the area would aid in understanding the downstream problem.

[*A spokesman from the Dept. of Environment, Canada provided the 500,000 cfs figure. It was his and the author understanding that this was the combined flow of the Ottawa, above Montreal, and the St. Lawrence, above Montreal. A footnote was added to clarify the text.*]

P.15 and 16 Recommendation 3-1 -

Canada does not control the Ottawa River. Most of the reservoirs on this river are in its upper reaches. There is a very large uncontrolled drainage area above Montreal. The land area contributing to the Ottawa River is about 50,000 square miles while the local land area contributing to Lake Ontario is about 27,000 square miles and the Ottawa River has no large storage like Lake Ontario.

[*The Commission feels that the problem is an international one and that the IJC should seek international solutions.*]

P.17 Finding 5 -

Further data gathering and analysis will not solve current problems. It might lead to better division of benefits under near normal conditions.

[*Division of benefits is one of the questions addressed by the report. The Commission agrees that improved data is part of the requirements to improve upon the existing division of benefits as you state in your comment.*]

P.17 Finding 6 -

Considerable flexibility exists at present, for example, discharges of 350,000 cfs in 1973 which were 32,000 cfs above the previous maximum and 40,000 cfs above the agreed to maximum.

[*Granted there is flexibility in this one aspect of the Plan of Control. However, there is zero flexibility in the Orders, and thus the Plan, with respect to the maintenance of a 27 foot navigational channel.*]

P.19 Finding 9 -

Agreed. This criterion was put in the Order of Approval to protect both

riparian groups knowing full well this protection is a compromise made in the light of the technical considerations of operation of the river. This criterion was enunciated with the knowledge that no plan of regulation can take into account every contingency of water supply.

[No comment.]

P.21 Recommendation 1-1 (c) -

Lake level forecasts are already an integral part of the regulatory procedure. These are not part of the regulation plan but are provided to the Board each month by its technical advisers.

P.21 Finding 2 -

Incorrect - current lake level forecasting techniques use hydrologic data but do not use meteorologic data. The state of meteorologic forecasting is such that little statistical significant benefit can be shown by the additional expense of incorporation of these data into the forecast. Even so the technical advisers receive rainfall and snow accumulation information routinely and base their advice on this. It must be understood that, on the average, 85% of the water supply to Lake Ontario comes from Lake Erie. Therefore, the forecast of this component is included in the present internationally agreed to forecast. Forecast of local supplies to Lake Ontario can make small improvements in the forecast procedure. It is difficult to prove that these small improvements in the forecast warrant a large expensive data gathering network. Technically, it is agreed that such a network is desirable.

P.22 Recommendation 2-1 -

There is a disadvantage to incorporation of forecasts in the plan of regulation in that an advance in the technology of forecasting would require going through the international red tape to change the plan of regulation.

P.22 Finding 3 -

We agree- however, to develope a meteorologic and hydrologic data collection system of sufficient density over an area of 300,000 square miles requires a lot of benefit to justify it. It is presently being improved in each country according to its priorities.

P.22 Recommendation 3-2 -

The Canadian lake level gauge system has been completely automatic since 1972. Data is available for the period ending at 0800 hours for the previous 24 hours from a computer data storage located in Toronto and accessible to anyone who provides himself with a terminal and contract with Dataline Systems Ltd. using the standard voice telephone service or telex. All Canadian gauges used in the regulation of Lake Ontario are on this system.

[The section on lake level forecast was revised in light of this and other information provided by reviewers.]

P.23 Recommendation 4-1 -

See comments on P.12 and P.17.

[*As stated throughout the text adequate data is required in order to know what the tradeoffs of any decisions are.*

Currently it is felt this data is lacking.].

P.25 2nd last sentence -

Incorrect - the International Rapids section extends from Ogdensburg-Prescott to the International Border at the entrance to Lake St. Francis from the south Cornwall channel.

[*Delineation of International Rapids Section clarified.*]

P.26 last sentence -

...."seasonal cycles and water supply from precipitation, the Great Lakes-St. Lawrence "....

[*Suggested phrase was added.*]

P.29 Figure 3 -

The drainage basin boundary looks very approximate and incorrect in the area north of Oshawa in Ontario. See Corps of Engineers Lake Survey Chart of Great Lakes.

[*Figure revised to more closely reflect boundary.*]

P.30 Table 2 -

For correct data see page 12, Regulation of Great Lakes Water Levels, report of the International Great Lakes Levels Board, 7 December 1973.

[*Table checked.*

The data presented was primarily from the source referenced and updated.]

P.33 Para, 2 L. 3 -

351,000 cfs daily maximum - due to rounding previous day 349,000 cfs. It is more significant to refer to monthly means i.e. 350,000 cfs as used in Table 2.

[*Reference in text is to the maximum mean daily flow which was 351,000 cfs.*]

P.33 -

Suggest adding under "Lake Levels" - Lake levels used in the International Joint Commission's orders are monthly mean values.

[*Added recommended sentence on page 157 (of draft).*]

P.36 -

A major cause of level rise in the lakes is the ice retardation in the connecting channels particularly in the Niagara and St. Lawrence Rivers. Without this the lakes would not start their winter and spring rise so early and the magitude of the rise due to snowmelt and precipitation would be much less. See paragraph 3, page 37.

[*No comment.*]

P.37 Para. 1 -

The regulation of Lake Ontario, under current operations, takes into account crustal movement.

[*Text was expanded to indicate that this factor is taken into account in lake regulation.*]

P.47 Para. 3 -

Who's rule? 80 percent should be more like 50 percent.

[*The rule of thumb was provided by Corps of Engineers personnel, Buffalo District Office.*]

P.51 Para. 2 -

The great rise in the levels of Lake Ontario takes place in the winter when the outflow from the lake is restricted by ice and is much less than the water supply to the lake.

The physical system - winter discharge capacity 1972-73 limited the amount of water which could be discharged. By spring it was too late, the lake had already done its damage on 17 March! The institutional arrangements did not limit the discharge until flooding was occurring downstream in April and May 1973. The physical dimensions limited the flow during the winter of 1972-73 and 1973-74.

[*This is realized. However, if the lake levels had been allowed to fall in the late summer and early fall of the preceeding year the Lake would have been able to absorb the expected rise without incurring damages to the extent that it did occur.*]

P.52 Para. 2 -

See comment for P.22, Recommendation 3-2.

[*Text changed to indicate that the Canadian portion of the system is automatic.*]

P.52 Section C -

There are more recent studies of forecasting lake levels - see International Great Lakes Levels Board report, Appendix A, Hydraulics and Hydrology.

P.63 -

It is obvious the writer is not familiar with statistics and the prediction of natural phenomena. By the very nature of a random event the average is the best predictor. The further you look in the future this is true and the analysis shown in Table 10, p. 61 shows that this statement is true. Our findings are that forecasts of lake levels can be made with value one month ahead due to the natural persistence in the system, after that, in the future six months the average becomes a better and better predictor in the future. If a bias is added, the error of long term prediction is multiplied.

[*The section on lake level forecasting was revised to incorporate your comments and those of other reviewers.*]

P.70 Figure 11 -

The profile of the St. Lawrence River is not a straight line to Cape Vincent. There is a small slope to Ogdensburg and most of the fall occurs Ogdensburg to Massena.

[*Figure 11 was modified as suggested.*]

P.71 Para.2 -

The minimum is not established by Plan 1958-D. Rather it is a requirement of the International Joint Commission's orders which specify the minimum profile of the river which will be adhered to for all discharges high or low.

[*The text was changed here and throughout to clarify the origin of the requirements set forth in the Criteria.*]

P.78 Para. 1 -

If such an ice dam occurred, it would be detrimental to riparians also since it limits the outflow from Lake Ontario.

[*No comment.*]

P.78 Para. 2 -

These desires of power are also requirements necessary to provide riparian benefits to Lake Ontario.

[*Your statement is partially correct. In periods of high water there is no benefit to power of flows above 325,000 cfs while there is to upstream riparian interests.*]

P.117 Para. (b)1st sentences -

See comment P.15.

The 500,000 cfs figure used is the total flow downstream Montreal.

The Montreal Harbour level, Figure 22, is not indicative of flooding problems in the Montreal area since it has been subject to flooding from ice jams in the past. The area sensitive to flooding where major damage occurs is below Beauharnois and above the Lachine Rapids. Lake St. Louis levels where flooding occurs are about 50 feet above the Montreal Harbour levels.

[*The text was expanded to clarify the flow figures. Figure 22 was removed from the text in light of your comment and others.*]

P.126 Para. 4 -

This paragraph reflects a basic misunderstanding of the relationship of the regulation plan to the requirements of the Orders of Approval of the International Joint Commission. These orders have the approval of the governments of Canada and the United States. The regulation plan is the plan of releases from Lake Ontario to comply with these orders. Releases since the fall of 1972 have seldom been the plan 1958-D releases rather they have been based on the physical capacity of the river or such as to minimize the adverse impacts on the various interests. The damages to the riparian owners and the natural environment were less than would have occurred without the project in place. The physical dimensions of the St. Lawrence River would not permit sufficient discharge to totally protect riparian owners.

[*The text was expanded to reflect the beneficial aspects derived from the Plan of Control. Also a discussion of the current physical limitations of the St. Lawrence River were included. However, the question still at issue is whether the Plan as implemented does minimize adverse impacts.*]

P.128 -

Well said!

Pages 128 and 129 are not compatible with the other inferences made in the findings and recommendations and other places in the report. There is not doubt that the regulation of Lake Ontario is not perfect and the principle reasons for this is given on pages 128 and 129. In all cases of both high and low supplies, regulation has provided better water level conditions than would have occurred without the construction of the project.

[*The Commission fails to see where incompatability arises. P 128 discusses the limitations of control plans-both from the structures required and the operating criteria.*]

P.129 Para. 1 -

The extremes are not left uncontrolled. Instead, the physical limitations of the discharge channel limits the amount of control which can be achieved.

[*This is one of the questions at issue. Given the current physical limitations of the St. Lawrence River, is optimal control being achieved? The Commission feels that the answer is no.*]

P.138 Section 1 - Man Made Facilities (a) -

Just as shore structural protective devices must meet rigorous economic criteria so the construction of the St. Lawrence Seaway and Power Project also had to meet rigorous economic criteria before it could be constructed.

[*This is well understood. The text here is merely saying that*]

[protection of the natural environment is dependent upon lake level regulations.]

P.140 Para. 2 -

Lake level regulation can never provide total protection. It can reduce the high levels and raise the low levels. There are too many unknowns in the future such as the vagaries of the weather to make such a claim. The general problem is that the riparian expects more from lake level regulation than can be delivered by the physical dimensions of the system. To totally control Lake Ontario would require another outlet from Lake Ontario of a similar magnitude to the St. Lawrence River.

[No comment.]

P.141 Footnote 1 -

This statement by the Corps of Engineers is based on internationally agreed to data on preproject levels in comparison with actual levels.

[No comment.]

P.146 Figure 28 -

Note Appendix "C" should read "D".

[Reference to Appendix corrected.]

P.157 Section A Para. 2 and 3 -

You must consider what 13 inches on Lake Ontario represents in discharge in the St. Lawrence River. It represents 100,000 cfs discharge for one month. Knowing the physical limitations of the St. Lawrence River and the amount of increase in capacity achieved by the excavations of the project, this represents a considerable achievement and leads to the conclusion the criteria was satisfied. All of the criteria with set limits are stated in terms of the supplies of the past as adjusted. This is defined in the International Joint Commission's orders. The only criterion which refers to the future supplies is criterion (k).

P.157 Section B -

The key words in this criterion are the words "with the supplies of the past as adjusted". The supplies of 1972 to 1974 exceeded the supplies of the past as adjusted and the plan did not meet this level. If the supplies were equal or less and the plan permitted the level to exceed 246.77 then the criterion is not met.

[In order to ensure that the reader is aware that the criteria are evaluated on the basis of supplies of the past a section stating this and the fact that precipitation in the Lake Ontario basin was above average during the period under study was added immediately preceeding the section on evaluation.]

P.158 Section 6 - Special Conditions -

The key words in this criterion is "all possible". This is the interpretation placed on this criterion by the International Joint Commission with the agreement of the Board.

The restrictions in flow cited on the bottom of this page and the top of the next were made to minimize adverse impacts on other interests. A more rigid interpretation would have maximized adverse impacts.

The outflow from Lake Ontario is controlled even with the power dam in place by the level of Lake Ontario. High levels permitted high outflows of 350,000 cfs. To continue such high flows into the late summer and fall months after Lake Ontario was below 246.77 would have maximized damage by causing prolonged flooding downstream and denied the use of the river to a large portion of the commercial navigation fleet since levels of Lake St. Lawrence would have been several feet below that which would provide safe depths. Currents would have similarly been worsened. The result was a compromise which must be made whenever high or low supplies occur.

[*See above comment.*]

P.210 -

Correct address - Mr. David F. Witherspoon
Engineer-in-Charge
Great Lakes-St. Lawrence Study Office
Environment Canada
318 Federal Building,
Cornwall, Ontario, Canada
K6H 5R8

[*Address was corrected in final report.*]

STATE OF NEW YORK
EXECUTIVE DEPARTMENT
OFFICE OF PLANNING SERVICES
488 BROADWAY
ALBANY, N.Y. 12207

HENRY G. WILLIAMS, JR.
DEPUTY DIRECTOR

January 15, 1975

Mr. William E. Tyson
Executive Secretary
St. Lawrence/Eastern Ontario Commission
317 Washington Street
Watertown, New York 13601

Dear Bill:

As requested, OPS staff has reviewed the Commission's report entitled "Analysis of and Recommendations Concerning High Water Levels on Lake Ontario and the St. Lawrence River." They found the report to be very factual, but the author should have expanded on several of his recommendations. Particularly, the author should have developed more details on how to accelerate implementation of the federal flood insurance program and related flood plain management, for he cited that such a program has not been adequately implemented.

[*The recommendations were reviewed and where appropriate expanded to include greater detail.*]

The reviewers also feel that the need for more data and the potential benefits of a revised regulating plan based on better data could be highlighted, maybe by giving it a more prominent place in the order of findings and recommendations and making it more explicit. The ideal would probably be a computerized model to assess effects of varying criteria for regulating the St. Lawrence. In this connection, adequate consideration of power production is of state-wide interest (see pp 91-98).

[*Recommendation 4 under Data/Research was expanded to include additional data requirements.*]

Other comments on recommendations are:

. (a) 1-3: consider dropping this; the flood insurance act requires notice through the mortgage bank now, and if recording is required in this case, why not for other hazards?

[*Recommendation 1-3 was dropped.*]

. (a) 2-1: riparian owners should have some input into how the St. Lawrence is regulated, but the exact manner of selecting representatives will require considerable thought.

[*The Commission is in agreement with this statement.*]

. (a) 4-1: should be corrected to include the latest provision of the 1974 Disaster Relief Act and the 1973 Flood Disaster Protection Act which essentially prohibit SBA "forgiveness" loans to property owners who do not have flood insurance.

[*Recommendation 4-1 was expanded to include reference to recent legislation.*]

. (a) 6-1, (a) 7-1, (c) 1-1 and wherever else it is appropriate; re-examination of the regulating plan should be continuous or undertaken periodically.

[*The text was revised to include the idea that the Plan should be continually revised.*]

. Finding (c) 4 should specifically mention electric power generation.

[*Recommendation 4-3 and 4-4 were added. The cost of alternative sources of power is included as a data need.*]

. p. 24 - state and local governments also have primary responsibility for recommendation (a) 1-1.

[*Table 1 was revised in light of your and other comments.*]

We are looking forward to the final report.

Sincerely,

Henry G. Williams, Jr.
Deputy Director and
Acting Director

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

Ogden Reid
Commissioner

January 15, 1974

Mr. William E. Tyson
Executive Director
St. Lawrence-Eastern Ontario Commission
317 Washington St.
Watertown, N.Y. 13601

Dear Bill:

In regard to your St. Lawrence-Eastern Ontario Commission draft report on Lake Ontario water levels, we are providing you with comments on your findings and recommendations. In general, we concur with the thrust of the recommendations. However, we have the following specific comments.

1. Page 14 The State and local agencies should have primary roles and responsibilities in cooperation with the Federal Government and the International Joint Commission in the development of plans for regulation of Lake Ontario and the St. Lawrence River. We wouldn't say that the responsibilities fall primarily on the IJC and Federal Agencies. The State and local agencies have prime responsibilities in the Coastal Zone Management, flood insurance and water quality programs that are directly related to the water levels study.

[*Table 1 was revised to include this and other points.*]

Institutions

2. Page 15, Recommendation 1-3 Recording flood hazard on property deeds would be desirable. However, it would tend to be expensive, perhaps, it could be required when property is transferred.

[*Recommendation 1-3 was dropped in the final report.*]

3. Page 15, Recommendation 2-1 There should be an IJC Investigative Board for the Lake Ontario-St. Lawrence River to include State and other non-Federal participants, particularly in the committee work of such a board. Also, the riparian owners and their interests should be represented on the committees as well as other interests, particularly representatives of environmental concerns. Adding local representation to the existing St. Lawrence Control Board which is basically an operating mechanism may be desirable. However, this kind of representation can be more effective on an Investigative

or Planning Board which is analyzing and recommending specific proposals.

[*Recommendation 2-1 was expanded to include an investigative or policy board with broader representation.*]

4. Pages 15-16, Recommendations 3-1 and 3-2 New York State should be adequately represented in any effort to develop an overall management program for the Lake Ontario-St. Lawrence River Basin. We have proposed further study of the possibility of control and remedial works in the St. Lawrence River through an investigative board with New York State membership. A revamping of the IJC institutional arrangement is not needed. It is true that the IJC has been too far removed from state and local interests and in the past has not involved public participation in the formulation of its proposals. Formation of an investigative board representing all interests should be the means to overcome past deficiencies.

[*Recommendation 3-2 was reworded to clarify the action the Commission felt were appropriate.*]

5. Page 17 Findings here and elsewhere in the report should be amended to include the recent Corps of Engineers proposal SEO-17P in combination with the modified plan 1958-D. Also, the development of a scope of work for the recent proposals should include environmental and economic studies which are required and are necessary to attempt to maximize net benefits, which is probably not possible because of the trade-offs required among economic, environmental, social and political considerations. In particular, environmental considerations require identification and quantification to the extent possible. Environmental studies are needed and the scope of work should be developed in order to determine what effects the proposed plan would have on wetlands and other environmental consideration. This identification should be done by the IJC with State and other non-Federal assistance. However, the cost of these studies should be Federal and funded through the IJC.

[*SEO-17P provides for a slightly differing plan of operation of 1958-D. However, the basic premise upon which SEO-17P was formulated is that the criteria set forth in the Orders of Approval be met. It is these criteria that the Commission feels need re-evaluation. In addition recommendation 4-3 and 4-4 were added. They indicate other data requirements.*]

6. Page 14, Finding 9 We interpret Criterion K to be possible from the viewpoint of providing consideration to both upstream and downstream owners.

[*The discussion of Criterion (k) was revised here and throughout the text.*]

7. Page 19, Recommendation 9-1 In view of the recent SEO-17P proposal, this recommendation should probably be changed. Also, there should be a recommendation which calls more specifically for an overall study of environmental effects of lake level regulations covering both high and

low water periods.

[*SEO-17P only examined the Criteria in light of whether they were met or not by SEO-17P. The Commission feels the Criteria should be re-examined in light of the passage of time, the record high lake levels and other considerations. Also Recommendation 4-3 and 4-4 were added.*]

Data Research

8. Page 21 We can't agree with the finding that the productivity of the natural environment of Lake Ontario is dependent upon regulation. Sufficient environmental studies have not been made to make a statement of this nature.

[*This finding was reworded to clarify what the Commission defines as the natural environment.*]

9. Page 21, Recommendation 1-1 alludes to some of the earlier recommendations under the institutional heading and is not specifically related to data and research needs. A list of environmental and economic research studies that are required should be given.

[*Your point is well taken. However, when categorizing items some do not fall in exact categories so they are placed where they most closely fit.*]

10. Recommendation 2-1 is questioned because we believe lake level forecasts are being used now in the decision-making process. There may be need for improvements and additional data, but we question the statement that current procedures do not utilize forecasts of lake levels.

[*The section on lake level forecasting was rewritten to include data on the currently used methods. However, it remains that lake level forecasts are not an integral part of the formal decision-making process.*]

11. Page 23, Recommendations 4-1 and 4-2 relative to the evaluation and benefits and costs of trade-offs are much more than the two listed on this page. Reliable flood damage information should be developed and trade-offs between economic and environmental considerations should be identified. In specific:

Recommendation 4-1 may be over simplistic. Stage-damage relationships should be established but this involves more than a curve, and Recommendation 4-2 should provide for studies of economic consequences relating to power generation, fish and wildlife, recreation and environmental factors in addition to navigation.

[*Recommendations 4-3 and 4-4 were added.*]

12. The finding should make more reference to the need for data on fish and wildlife resources, wetlands, recreation resources, which are required for full evaluation of alternative regulation plans.

[*(See comment above).*]

13. Page 24 State, regional and local primary responsibilities are more than those indicated in the Table. We have indicated some suggested additions in the enclosure.

[*Table 1 was revised in light of your and other comments.*]

Thank you for the opportunity to review this draft report.

Sincerely,

J. A. Finck
Assistant Director for
Plan Development

Enclosure

cc: T. Eichler
H. Williams
E. Rich
E. Karath
C. Morrison
J. Wilson
H. Doig

Suggested additions (X)

Table: 1 Level of Government Holding Primary Responsibility for Carrying Out Recommendations

Level of Government -	Recommendations[a]													
	Institutions													
	1-1	1-2	1-3	2-1	3-1	3-2	4-1	4-2	5-1	6-1	7-1	7-2	8-1	9-1
Federal	x	x	x	x	x		x	x	(X)	x	(X)	(X)	x	(X)
State	(X)	x	x			x				(X)	(X)	(X)	x	(X)
Regional		x											x	
Local	(X)	(X)											x	
International				x	x				x	x	x	x		x

	Physical Works				**Data/Research**						
	1-1	2-1	2-2	2-3	1-1	2-1	3-1	3-2	4-1	4-2	5-1
Federal	x	x	x	x	x	(X)	x	x	(X)	(X)	x
State	x	x	x	x	(X)	(X)	(X)		(X)	(X)	
Regional			x								
Local	(X)		x								
International					x	x			x	x	

[a]The recommendation numbers refer to those listed in I, Findings and Recommendations, of this report.

Great Lakes Basin Commission

January 16, 1975

Mr. William E. Tyson
Executive Director
St. Lawrence-Eastern Ontario Commission
317 Washington Street
Watertown, New York 13601

Dear Mr. Tyson:

Your letter of December 18, 1974 to Mr. Crook requesting technical review of a "Draft Document" entitled, "Analysis of and Recommendations Concerning High Water Levels on Lake Ontario and the St. Lawrence River" dated December 1974, has been referred to me for reply.

I have briefly reviewed the "Draft Document". I consider it to be a compilation of valuable information as set forth in your statements of findings and recommendations. We agree that the regulation of Lake Ontario, as well as the whole Great Lakes system, entails extremely complex engineering plans and institutional arrangements. Because of this and the somewhat cursary nature of my review made necessary by other business, I am reluctant to insure that your analysis of the situation is completely technically correct, and by so doing, sign off on your "Draft Document".

The Great Lakes Basin Commission is vitally concerned with further regulation of the Great Lakes. The Commission members are well aware of the damage which has occurred to riparian owners due to unusual amounts of precipitation and reduced amounts of evaporation together with the strong winds accompanying the storms that have occurred in the past several years. For this reason, the Commission appointed an Ad hoc Review Committee to review the Main Report of the Lake Levels Board to the International Joint Commission together with the appendices.

The Ad hoc Review Committee met on October 16, 1974 and developed a set of recommendations for presentation to the Great Lakes Basin Commission relative to the regulation of Great Lakes water levels. Mr. William Daley, of New York State, is a member of the Ad hoc Review Committee. Recommendation No. 2 is

3475 Plymouth Road, Post Office Box 999, Ann Arbor, Michigan 48106
313/763-3590 FTS: 313/769-7431

addressed to the regulation of Lake Ontario water levels. It reads as follows: "The Commission endorses the recommendation for further study and evaluation of the regulation of Lakes Erie and Ontario water levels to insure that apparently reasonable alternatives, in addition to SEO-42P, receive adequate consideration. However, benefits should not be derived from substantial lowering of long-term mean and low levels of Lake Erie."

In conversation with Mr. Daley during the progress of the meeting, he indicated that conditions in the St. Lawrence River are the major constraints to regulation of Lake Ontario. The Main Report recognizes that the physical dimensions of the St. Lawrence River are inadequate to accommodate the record supplies to Lake Ontario received in 1972-1973 and, at the same time, satisfy all the criteria and other requirements of the IJC Orders of Approval for the regulation of Lake Ontario.

I have not had the benefit of comments from Mr. Daley or other concerned Committee members relative to the analysis of your recommendations concerning the high water levels on Lake Ontario and the St. Lawrence River as set forth in your report and, therefore, we do not wish to express a Commission position without the benefit of Mr. Daley's input.

I would comment on your point, expressed as the third item on page 12, relative to riparian owners being represented on the decision-making body that determines the mode of operation of the Plan of Control. It is our understanding that there have been opportunities for some degree of representation. The State of New York, who could represent the riparian owners, has been previously invited to name a member to the St. Lawrence River Board of Control. We note that there are presently only three U.S. members on the Board.

As I indicated earlier, I believe that this document contains much valuable information and would be a good guide to other Great Lakes states for developing additional legislation and institutional arrangements. We would like to request that when you have the final document prepared, that copies be furnished to all members of the Commission's Ad hoc Review Committee. This document will be valuable to further consideration and deliberations of the Committee relative to their responsibility to make whatever additional recommendations they deem to be desirable to the Great Lakes Basin Commission.

For your information, I am attaching a copy of the recommendations adopted by the Commission at their November 20 meeting. These were forwarded to the IJC for their information and use.

We are pleased to have received a copy of the Draft Document and we will appreciate your cooperation in making the Final Report available to the attached list of the Ad hoc Review Committee members.

Sincerely yours,

John L. Hull
Comprehensive Basin Planner

Enclosures: as stated.
cc: Mr. William Daley

POWER AUTHORITY OF THE STATE OF NEW YORK
10 COLUMBUS CIRCLE NEW YORK, N. Y. 10019
(212) 265-6510

January 17, 1975

Mr. Joseph Romola
Chairman
St. Lawrence - Eastern
Ontario Commission
317 Washington Street
Watertown, New York 13601

Dear Mr. Romola:

The Power Authority of the State of New York has reviewed your Commission's draft "Analysis of and Recommendations Concerning High Water Levels on Lake Ontario and the St. Lawrence River".

In general terms, the report recommends changes in the present scheme for regulating Lake Ontario to provide additional protection to riparian owners. However, the report does not recognize that such changes could only be achieved by imposing severe adverse effects on others, namely, downstream riparian owners, navigation and power generation in New York, Ontario and Quebec.

[*The report does not make the recommendation as stated. It does recommend that the current method of lake regulation be re-examined and that the lake levels be regulated with the objective of minimizing total damages. In addition to lake level regulation other methods of damage reduction are assessed.*]

The report, in making such recommendation, fails to reflect an understanding of the provisions of the 1909 Boundary Waters Treaty and of the function of the International Joint Commission in acting for Canada and the United States in both devising the criteria governing regulation and in conducting the present regulatory scheme to meet the objectives contained in the criteria.

[*The provisions were understood. The question at issue is whether*]

[the Criteria are still applicable due to the passage of time and the high water levels experienced.]

By way of background, during the 1954-58 period, the Authority, together with its Canadian partner, Ontario Hydro, built the St. Lawrence power facilities.

The power facilities represent an investment of over $700-million 1958 dollars. Together with the Seaway facilities, financed by the two federal governments, the total investment on the St. Lawrence in structures which make Lake Ontario regulation feasible exceeds $1-billion 1958 dollars.

The International Joint Commission, acting for the two governments, implemented a plan of regulation for Lake Ontario in 1960. The original plan (1958-A) and its successors (1958-C and 1958-D) have, over the past 15 years, been successful in providing a more beneficial range of levels on Lake Ontario than would have occurred under natural conditions. Official government records indicate that monthly mean Lake Ontario levels over this 15-year period would have varied from 241.61 in January 1964 to 249.02 in May 1973 if regulation had never been implemented. With regulation, the range of levels has been from 241.78 to 247.92. The riparian owners on the lake and in the upper river have received this benefit.

[The text was expanded to reflect the beneficial aspects of the current Plan of Regulation.]

We think your Commission should recognize that the investment in both power and navigation facilities was justified because of the assurances provided by the criteria approved by the International Joint Commission. In other words, a regulation scheme to indicate the probable levels and flows was necessary for both the economic analysis and the design of the project. To suggest now, 15 years later, that the riparian interests should have further benefits, is really to suggest that the two countries alter the basic conditions under which the St. Lawrence facilities were financed and constructed.

[We have not suggested that riparian interests be given further benefits specifically. What is suggested is that the flood damage reduction techniques be applied with the objective of minimizing the adverse impacts.]

Further, although your report does not do so, it should be brought to the attention of the Legislature that to confer additional benefits to the riparian interests on Lake Ontario beyond those specified by the IJC's criteria would have serious

adverse effects on other areas of the New York State economy. Further compression of the range of stage on Lake Ontario would doubtless confer additional benefits to riparian interests there but given the present physical channels and structures, would simultaneously reduce the output of low-cost power from the St. Lawrence and reduce drafts for commercial navigation - both of which would adversely affect New York State. By reducing hydro electric generation, such a proposal would seriously affect efforts in New York to conserve fossil energy sources. It therefore seems fair to ask whether your Commission should advocate such a course to provide additional benefits to that small percentage of the population who live along the shoreline.

The question at issue is "What are the trade-offs involved?" Is the benefit derived from using low cost hydro power compared to fossil fuels less, greater or equal to the damages incurred by its use; are the benefits of navigation in the Seaway less, greater or equal to the costs incurred by maintaining a 27 ft. channel? These are the data that must be determined in order that rational trade-offs can be made in order that total adverse impacts can be minimized.

The implication that because the Authority generated record amounts of low-cost energy in 1973 and 1974, it realized "windfall gains" is simply not true. As a matter of fact, in both 1973 and 1974 water equivalent to over one-half billion kilowatt hours was spilled at Long Sault Dam to provide relief to the riparian interests on Lake Ontario. If the water which was spilled could have been used to generate electricity over a million barrels of oil might have been saved. Surely your Commission is aware that Authority power is sold without profit and at rates lower than any alternative sources of power available to New York State users.

In the discussion of "Interest Groups Affected" the power interests considered were not only the producers but also the consumers of power. As stated on pg. 98 the consumers achieved about 5 million dollars of savings due to PASNY producing above average power.

Secondly, if this water had not been spilled over Long Sault Dam is the data base available to tell what impact it would have had on water levels and thus damages. Possibly the damages would have been greater than the cost of million barrels of oil saved. This is the question the Commission would like to see addressed.

In summary, the Authority feels that your Commission has a responsibility to present the full picture to the Legislature and that your draft report falls short of meeting that responsibility. The power and seaway facilities which make

Lake Ontario regulation feasible were constructed only because of commitments by the two federal governments to regulatory schemes designed to meet the IJC's criteria. The course you now advocate to provide more protection for riparian interests on Lake Ontario and in the upper St. Lawrence would seriously jeopardize that investment, impose serious economic penalties on the users of Authority energy, would require the consumption of additional fossil fuels to replace lost hydro energy, would adversely affect the navigation community in the Great Lakes, and would impose added flooding on downstream riparian owners. We ask that you consider whether this course of action is in the best interests of the State of New York.

[*The Commission would like to ask the following question: "How does managing lake levels in a manner that minimizes adverse impacts lead to the results set forth in the summary paragraph?"*]

Attached is a list of major technical errors we have found in the draft.

Sincerely,

James A. FitzPatrick
Chairman

Attachment

MAJOR TECHNICAL ERRORS NOTED

Page 51: There were no known institutional restraints which prevented more rapid discharge of water in 1973 and 1974. Flows during the spring and summer months were designed to minimize flooding problems both upstream and downstream while fall flows were those which provided design depths for Seaway navigation; higher fall flows would have resulted in restricted drafts for navigation.

[*The institutional constraint referred to is the required maintenance of a 27 foot navigation channel. The Commission feels that the cost-benefit relationship of this should be examined.*]

Pages 71 & 72: The discussion relative to the effect of changes in flow is somewhat misleading. Normally, flow changes are effected at Moses-Saunders at midnight on Friday and our records indicate that only about 48 hours are required to establish the new regime throughout the river. The flows released in 1973 and 1974 could have been considerably higher but would have either caused downstream flooding or would have restricted seaway draft.

[*The text in this section was modified to clarify the discussion.*]

Page 74: The Moses-Saunders Powerdam has the capability to pass flows up to about 325,000 cfs. While the number of kilowatts per cfs is maximized at a flow of about 270,000 cfs, it is not true that flows above 270,000 cfs have zero value for power production.

[*The text on page 74 of the draft was revised to reflect this comment.*]

Pages 76 & 78: As regards the winter season, the project channels were designed to provide water velocities no greater than 2.25 fps with a flow of 220,000 cfs, the maximum specified by the plan of regulation throughout the month of January. Over

the past few years we have found from experience that we can form a satisfactory cover with flows in the order of 235,000 cfs.

[*The text was revised to reflect this information.*]

Your statement midway on Page 78 that the winter months are those of peak demand is not accurate - the Authority's firm contracts for firm power require that the Authority deliver fixed quantities of energy throughout the year.

[*Footnote #3 was added to reference the source of the statement that peak demand for electric production of the PASNY system is in December. Your comment on the Authority's firm contract for firm power is included since this power is an element of the peak demand.*]

Page 87: We question your conclusion that only 2% of the shoreline between Cornwall and Montreal is considered erodible. The shoreline of Lake St. Francis is very flat and even though Hydro Quebec holds the lake levels within a band of about one foot, flooding and erosion do occur. The highly developed shoreline of Lake St. Louis below Beauharnois is also subject to flooding and erosion with combined St. Lawrence and Ottawa flows in excess of about 350,000 cfs.

[*As indicated in the source of Table 16 the data on the Canadian shorelines was obtained from Canadian sources. Time prevented us from gathering data ourselves.*]

Page 98: Using your own figures from Table 20, you considered 1970 and 1971 as average years. During those two years, the Authority's revenue from the sale of St. Lawrence power averaged $29.3 million. Our revenue in 1973 from St. Lawrence was $32.2 million and it is expected 1974 revenues will be slightly less than for 1973. This hardly constitutes a 20% increase in revenue.

[*The text in this section was changed to reflect the data provided. This data indicates a 14% increase in revenue.*]

Page 126: Contrary to the paragraph at the bottom of the page, releases from Lake Ontario through the Moses-Saunders Powerdam have not been in accordance with Plan 1958-D to the point where

the Lake Ontario level on December 27, 1974 was 3.6 feet lower than it would have been if Plan 1958-D had been strictly followed. You should understand that the alternative to what you have termed "windfall gains for power" would have been to have spilled the water. Would this have been a logical decision in view of the high cost of alternative power sources?

[*The text was revised on page 126. A section was added including Figure 29 discussing the benefits of Plan 1958-D. Figure 29, which reflects preproject and regulated levels, indicates that the difference in Lake Ontario's level at the end of September 1974 was only 2.17 feet.*

With the limited data available the Commission feels that a judgement cannot be rendered relative to the question asked. As pointed out in the text the lack of data on the cost of alternative fuel sources compared to the different modes of implementing lake level control, including "spilling" greater quantities of water, cannot be made due to the lack of data.]

Pages 152 & 153: In the tabulation relative to enlargement of river channels, you have included the excavation of 25 million cubic yards to form the Wiley-Dondero Canal. This canal was principally excavated through the U. S. mainland and did not affect the hydraulic capabilities of the river channels.

[*Text expanded to incorporate this information.*]

Pages 153 Thru Page 159: In evaluating the degree to which operations of 1973 and 1974 met the objectives of the IJC criteria, you apparently have concluded that the limiting elevations contained in Criterion h, i, and j are absolutes - they are not. The Commission, in its wisdom, indicated that regulatory schemes were to meet certain objectives, assuming that the supplies of the past were representative of what would occur in the future. However, the Commission also indicated that in the event of future supplies outside the range of previous experience, the regulation procedures should provide all possible relief to the various interests in recognition that nature is unpredictable.

[*A section, preceeding the evaluation of the criteria, was added to address this topic.*]

INTERNATIONAL
ST.LAWRENCE RIVER BOARD OF CONTROL

January 17, 1975

Mr. William E. Tyson,
St. Lawrence --Eastern Ontario Commission,
317 Washington Street,
WATERTOWN, New York, 13601,
U.S.A.

Dear Mr. Tyson:

I wish to acknowledge your letter of December 18, 1974, enclosing a draft document "Analysis and Recommendations Concerning High Water Levels on Lake Ontario and the St. Lawrence River" dated December 1974. Review and comment by appropriate agencies and individuals was requested prior to finalizing this document.

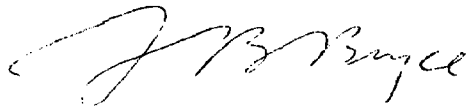
I have reviewed the document with interest, and as your letter was addressed to me as a member of the International St. Lawrence River Board of Control, I have forwarded certain comments to Mr. R.H. Smith, Chairman, Canadian Section of the Board.

The document contains a comprehensive review of regulation of Lake Ontario and the St. Lawrence River particularly during the recent high water period. As a general personal comment, I would say that the findings and recommendations with respect to regulation are written very much from the standpoint of upstream riparian interests, which unquestionably are important. In my view, however, there is not adequate recognition of the basis of the present regulation, the benefits that have resulted and the limitations that exist. Regulation of this nature is unavoidably complex in view of all the interests and factors involved.

The report was expanded to include more detailed reference to the areas pointed out in your comments. This was accomplished by adding Appendices D and F, Office Consolidation of Order of Approval and the Text of the Treaty of 1909 respectively. In addition a section was added discussing the beneficial aspects derived from the current Plan of Operation and the limitations that now exist.

I wish to thank you for forwarding the draft document to me.

Yours very truly,



J.B. Bryce
Member, Canadian Section
International St. Lawrence
River Board of Control

Environment Canada | Environnement Canada
Environmental Management | Gestion de l'environnement

Your file Votre référence

Our file Notre référence

Ottawa, Ontario
K1A 0H3

January 17, 1975

Mr. William E. Tyson
Executive Director
St. Lawrence-Eastern Ontario Commission
317 Washington Street
Watertown, New York
U.S.A. 13601

Dear Mr. Tyson:

Thank you for sending me a draft copy of your report "Analysis of and Recommendations Concerning High Water Levels on Lake Ontario and the St. Lawrence River". It must be understood that it is inappropriate for me to comment upon the report in my capacity as a member of the Canadian Section of the Great Lakes Levels Board and it must also be understood that my remarks cannot be construed as representing the official position of the Canadian Government. However, as an engineer who has been involved with water resource development for over twenty-five years, and who has also been associated with the Great Lakes for a number of years, I offer the following comments.

This document appears to be largely a synthesis of various other reports and does not seem to add anything new. I am not certain that the author truly understands much of what is currently being done in the area. For example, his comments on pages 52 to 63 reviewing levels forecasting speaks of a bias because of the use of 50% probability of precipitation in estimating future lake levels. This comment ignores the fact that the International St. Lawrence River Board of Control in its projections of lake levels uses three basin supply projections - 95% exceedence level, 50% exceedence level and 5% exceedence level. In other words, a range of levels are forecast to reflect high, low and medium supplies to the Lake. With the present state of knowledge on long term (up to six month) weather forecasting, this appears to be the only logical assumption.

The section on forecasting was revised. It remains as stated in the draft that the lake level forecasts are not directly tied into the Plan for lake level regulations. Secondly, since the

..../2

lake forecasts issued by various agencies have not been adequate in the past it is still recommended that additional research be done to improve them. (see Appendix B, Studies and Reports Underway and Regulation of Great Lakes Water Levels, Appendix A, pp. A55-A56).

The author's remarks on pages 128 and 129 about regulation plans left me wondering if he thoroughly understood the subject. For example, in the first full paragraph on page 129, he speaks of ranges of levels and extremes of levels when in actual fact it is the range of water supply which is the uncontrollable variable. He speaks of extremes which could "reasonably be expected to occur" without indicating how these would be determined. I would point out that the recent high flows to Lake Ontario have exceeded any known flows in the last hundred years. I certainly expect that at some time in the future even the high flows of the past three years will be exceeded but I do not know if this fits the author's concept of "reasonably expected".

Text changed on page 129 and other places to reflect supplies vice levels. "Reasonably expected" was defined.

Although there is a determined relationship between supplies and levels when operated within the framework of a regulation plan it is more explicit to discuss the subject in terms of supplies.

The above are only examples of two areas where I feel the author has failed to grasp the significance or to fully understand the material which he is treating. I have not had the time to give the report the thorough review required to permit me to discuss it at length. However, before closing, I would like to deal briefly with the findings and recommendations.

(a) Institutions

1. I agree whole heartedly with the author's finding No. 1 and his recommendation 1-2. These echo the Great Lakes Levels Board Report and my personal conviction. It is inappropriate for me to comment on recommendation 1-1 and 1-3 as these are internal U.S. matters.

[No comment.]

2. I do not agree with this suggestion. The present governmen t representatives on the Board are there to look at all interests. There would be considerable difficulty in selecting representatives for specific interests; also such representatives would then tend to seek benefits for their specific interests at the expense of others. Such a situation would lead to interminable wrangle and would not necessarily produce an overall improvement in the results.

[The Commission's position remains as stated.]

3. The control of flows in the Ottawa River is a Canadian matter and cannot be subject to the wishes of an external board. Specifically,

I cannot agree with the author's recommendation 3-1, particularly his final phrase "increases the probability" which suggests that it makes the situation on Lake Ontario worse. This is not so; it in fact limits the opportunities to "make it better". I am totally opposed to recommendation 3-2. Obviously, the author has not made a study of the IJC's history, duties or accomplishments. If he had, he would realize the value of this Commission in dealing with water problems along our mutual border.

[*Recommendation 3-2 was reworded to clarify the Commission's position.*

Precedent has been set in Columbia River, for international development of river basins. It is felt that the Great Lakes-St. Lawrence River - Ottawa River system should be examined in terms of such an agreement to determine if it would result in increased benefits to both countries.]

4. Strictly a U.S. recommendation and I have no comment.

[*No comment.*]

5. Again, I would suggest that the author has not reviewed and does not understand the IJC's role and functions. He does not understand its relationship with the relevant government operating agencies who do the data collection. I do not agree with the suggestion that the IJC be allowed to develop into another bureaucracy by having to assume functions of this type.

[*It is felt that adequate data is not available to the IJC. This being the case, they should initiate effort to obtain such data. These efforts could be in the form of financial aid to other agencies, collecting it themselves or however the IJC feels it should be accomplished.*]

6. This recommendation and finding appears to be a "motherhood" statement and appears to offer little of substance.

[*It is important to point out the fact that the SLRBC has stated repeatedly that they have flexibility and options and that they have used them to the fullest. At the same time the natural environment of Lake Ontario was sustaining damages.*]

7. Like recommendation No. 6 this offers little new.

[*It is of importance when the basic philosophy of regulation is subject to question.*]

8. This applies largely to U.S. internal matters.

9. Again the author appears to misunderstand Criterion k. He has drawn what I view to be an incorrect conclusion that Criterion k is inconsistent and cannot be satisfied. This appears to stem from his interpretation of the words "all possible". Instead of giving relief to either upstream or downstream interests to the detriment of the other,

the intention is to operate as equitably as possible with respect to the problems in both areas.

[*The discussion of Criterion (k) was revised in the text and in the list of Findings and Recommendations.*]

(b) Physical Works

1. A U.S. matter

2. Also a U.S. matter

[*No comment.*]

(c) Data/Research

1. This appears to be repetitious of earlier recommendations. All the author is really saying is re-evaluate Plan 1958-D.

[*The findings differ although the solution remains the same - thus repetition occurs.*]

2. Again I repeat the author does not appear to be familiar with all the facts. The Board of Control does recognize in its projections anticipated water supply conditions and sets its discharge levels accordingly.

[*Currently the Plan of Control does not call for, nor require lake level forecasts. It is being suggested that this be made a formal part of the regulation plan.*]

3. This is similar to recommendations made by the Great Lakes Levels Board.

[*No comment.*]

4. May be some merit in this approach.

[*Efficient, effective management of the Lakes requires this data base which appears to be currently lacking.*]

5. This is a U.S. matter.

[*No comment.*]

Time has not permitted as detailed an examination of this report as I would have liked. My comments are, therefore, in the somewhat hasty once-over-lightly category. In summary: Even recognizing that the author had a tough assignment in exploring such a complex area apparently within such a short time frame, the result is not an authoritative work and adds virtually nothing to the state of knowledge on this subject nor does it make any substantive suggestion for improvement.

Yours sincerely,

N.H. James
Director
Water Planning and Management Branch

DEPARTMENT OF TRANSPORTATION
ST. LAWRENCE SEAWAY DEVELOPMENT CORPORATION
WASHINGTON, D.C. 20590 MASSENA, NEW YORK 13662

Massena, New York
January 20, 1975

Mr. William E. Tyson
Executive Director
St. Lawrence-Eastern Ontario Commission
317 Washington Street
Watertown, New York 13601

Re: "Analysis of and Recommendations Concerning High Water Levels on Lake Ontario and the St. Lawrence River" - (Draft) by St. Lawrence-Eastern Ontario Commission - December 1974

Dear Mr. Tyson:

As requested in your letter of December 18, 1974, the Saint Lawrence Seaway Development Corporation, being fully aware of the importance of your final document to represent technically correct information and/or data, submits for your consideration and incorporation into the final report the following comments. Unfortunately, a detailed review was not possible due to lack of time and thereby prevented possibly a more comprehensive response on my part.

At the outset, I would like to commend Dr. Daniel J. Palm on the compilation of an intricate engineering matter concerning proper Lake Ontario regulation into a fairly comprehensive report. Since water regulation is a complex issue and consumes a considerable amount of our staff's time and efforts, I can appreciate the extensive time and effort that Dr. Palm has expended in gathering background data and information for preparation of the report.

As stressed throughout the report, the regulation of Lake Ontario entails extremely complicated engineering criteria and demands that attention be directed to many factors and considerations. A plan of regulation which fully solves the problems of one particular interest may have a disastrous effect on the affairs of a large number of other interests. This is an important point that I feel the author has completely ignored.

In order to remove the inference that one group is being given preference the introduction was rewritten. In doing so equal emphasis was placed on the 3 methods of damage reduction. In addition the discussion of the effectiveness of Plan 1958-D was moved to the chapter discussing lake level regulation. The text

was also changed throughout to reflect more clearly that the Commission views the objective of regulation to be the minimization of adverse impacts.

The regulation of Lake Ontario is indeed intricate and, in this vein, I would like to recommend that a review of the film "Not Man's to Command", produced and distributed by Environment Canada, be undertaken by your staff. This is a fine and technically correct production and may provide further insights into the subject matter and which may require that the general mood of the report be altered to present a more accurate representation of all interest groups. I would also suggest that you recommend to the appropriate office in Albany that they also view this film.

My initial impression, after a review of the report, is that it fails to properly appreciate the expertise of and the time spent by, together with the lack of bias of, the various representatives responsible for the overall success of the plan of regulation since its inception. The report only dwells on the minimal shortcomings of the plan of regulation during a period when nature provided an inordinate amount of precipitation. The report also fails, I believe, to recognize the ability of the plan of regulation to cope with these recordbreaking amounts of precipitation, for without the project and the plan of regulation, riparian interests would have suffered to a much greater extent. In this regard, it is interesting to note that the report does not address the fact that both navigation and power interests acceded to the direction of the St. Lawrence River Board of Control and worked together for the benefit of the riparian owner, when in 1973 and 1974 water was allowed to spill over Long Sault Dam -- water which then could never produce power and water which did, in fact create severe navigation problems.

Item 3 in the introduction to this Addendum clarifies the Commission's attitude toward the representatives responsible for the implementation of the Plan. Also a section was added describing the beneficial aspects of the Plan and the existing limitations to control.

The Seaway was constructed as a joint undertaking between the Saint Lawrence Seaway Development Corporation of the United States, and the St. Lawrence Seaway Authority of Canada. Both entities are intended to be self-supporting and self-liquidating through fair and equitable tariffs of tolls and charges for use of the Seaway facilities. As pointed out in the subject report, the approximate cost of constructing the Seaway project was about $470 million, of which Canada paid approximately $340 million and the United States approximately $130 million. As you will readily agree, the St. Lawrence Seaway is the economic lifeline to the Great Lakes Region and, when it was completed, the Seaway stood as a symbol of U.S. and Canadian efforts to create a waterway "for the mutual benefit of their peoples". The Seaway was hailed as "one of the greatest achievements for the advancement of our nation" and "the arrival of a miracle". Generally speaking, the development of the Seaway and the economy of the nation were (and are) intertwined. In retrospect, I can only observe that the "miracle" is still with us; and to any informed observer, it has been, without a doubt, a success.

The plan of regulation which I believe your draft report unfairly criticizes has also been a success, for without the project, the plan of regulation and the successful implementation of the plan of regulation, you and I would have seen and would still be seeing a disastrous flood condition along the shores of Lake Ontario and the St. Lawrence River.

This comment addresses one of the questions raised in the report. Granted the Seaway is important but what is the magnitude of this importance. This and other data are required to allow informed decision making.

While I would not argue with Dr. Palm's conclusion that "...riparian owners are a major interest group influenced by the water levels of Lake Ontario and the St. Lawrence River", I have been advised that such a group represents less than one percent of the total population of the Great Lakes area. This fact must be continually kept in mind when we consider the millions of people in both the United States and Canada who receive, either directly or indirectly, economic benefits of the Seaway/Power Projects.

The question is not the number of people in each group but the magnitude and incidences of damages due to high water.

The Seaway and Power Projects were designed and constructed under specific design criteria which, among other engineering considerations, were not arrived at for the benefit of navigation and power solely, but for all interests, including riparian owners as well. For the report to say that riparian owners are not represented by a spokesman of their own is a grave error, for we believe that the Corps of Engineers, among others, has clearly indicated its concern for riparian interests. Furthermore, we understand that Mr. Robert D. Conner is charged with the responsibility of representing the people of the State of New York.

Again reference is given to item 3 in the introduction to this Addendum.

Contrary to the report, the plan of regulation has determined, for regulation purposes, specific water levels, velocities and flows for optimum operation. As evidence of the concern shown for riparian owners, it should be remembered that the Seaway entities, during the 1973 and 1974 periods of high water, issued and effectively enforced speed restrictions on the river to minimize damage to the shore. These speed restrictions were very costly to shipping interests. It should also be noted that draft limitations for navigation were established based on the minimum profile of the St. Lawrence River established in the plan of regulation.

It is not debated in the report that Plan 1958-D has specific guidelines for optional operation given Criteria A-K. What is contented is whether this optimum operation was achieved and whether the criteria now require re-examination in light of the passage of time and the record high water levels recently

experienced. Shipping costs were well documented on pages 99-109. It is institutional constraints such as specific draft limitations that are under question in this report.

These same levels and flows criteria which the Seaway operations are based upon were affected by above average precipitation within the entire Great Lakes Basin. The Corporation reacted to this unprecedented supply situation and permitted flows greater than average and above that called for in the plan of regulation in an attempt to lower Lake Ontario. These higher flows were permitted up until the time that they affected the minimum profile and established draft limitations for navigation. It should be noted that these high flows further complicated the downstream flooding conditions experienced in the Montreal-Lake St. Louis area, which was already receiving a high supply flow condition from the Ottawa River. I felt that navigation should not be expected to carry the brunt of man's inability to forecast periods of high precipitation; consequently, flows were established in order to maintain the minimum profile during the late Fall of the time in question, inasmuch as above average precipitation values were not forecast and, furthermore, flooding was not occurring in any upstream/downstream areas during this same period.

It is not the intent of the report's recommendation to pass the "brunt of man's inability to forecast periods of high precipitation" onto navigation. It is the intent of these recommendations to devise a program of flood damage reduction where the adverse impacts are minimized. See pages 8-10, 47-51, and 99-109 also (draft).

The loss to navigation by a reduction in the draft limitations can be determined by a number of mathematical means; however, a channel depth-economic impact relationship would vary with time, depending on the number and mix of the transiting vessels. For example, it has been recently estimated that the value of a ton of cargo to the regional income of the Great Lakes area is $5 and $24 per ton, as produced from servicing bulk and general cargo, respectively. Any reduction in vessels' drafts would naturally directly affect the regional income. As previously pointed out, riparian interests represent less than 1% of the total population of the Great Lakes Area, while the total population of this same area represents 30% of the nation, which produces approximately 30% of the North American personal income.

The figures given in your comment do not address the question of magnitude of impact. This is the issue. The magnitude should be determined so that trade-offs can be determined in an informed rational manner.

Additionally, it must be pointed out that operating the Seaway at the minimum profile, as was done during the Fall of 1972, 1973 and 1974, places navigation in a very serious economical situation. For, at this minimum profile, Lake St. Lawrence is very sensitive to meteorological effects and any shifts in the wind to a north, northeast or east direction drops the water levels below the minimum profile. Vessels

are then ordered to anchor until the wind shifts, thereby allowing a return to the minimum profile and in turn a resumption in normal traffic. During one low water period spanning approximately a 46-hour duration over the 1st, 2nd and 3rd of December 1974, a total of twenty-seven commercial vessels were affected, resulting in a total lost time of 1165 hours to the shipping trade, or an equivalent loss, using Dr. Palm's operating costs per hour, (Table 23) of approximately $350,000.

[*The economic impact provided in your comment was added to the text.*]

Furthermore, operating at the minimum profile is operating at the minimum level of safety on the Seaway. This safety factor could contribute to loss of cargo and property, pollution of the environment, loss of human life and substantial increases in the insurance rates for shipping interests.

[*No comment.*]

One of the major errors in the report and one that affects the total validity of the entire report is the finding that "Flooding occurs in the Lake St. Louis-Montreal section of the St. Lawrence River when the combined flow of the St. Lawrence River and the Ottawa River exceeds approximately 500,000 cfs". It is generally accepted and so stated in the operational plans that flooding occurs in the Lake St. Louis-Montreal section of the St. Lawrence River when the combined flow of the St. Lawrence River and the Ottawa River exceeds approximately 345,000 cfs. When this figure is reached, the Operations Advisory Group selects the highest possible flows for the St. Lawrence River in order to minimize flooding upstream of the power dam, and at the same time being mindful of the possible flooding downstream of the power dam. During this critical period, flows are selected based on solely riparian interests.

[*The author realizes that the total flow of the Ottawa River does not reach the St. Lawrence River above Montreal. Footnote 12 in Chapter IV clarifies the conditions under which flooding occurs in the Montreal Harbour area.*]

In reference to criticism of the current plan of regulation, we find it extremely unfair to use damage figures accumulated during the storm in the Spring of 1973 in an attempt to establish the plan's inadequacies without assessing the positive benefits that the same plan of regulation has afforded riparian interests over the years. If the plan is inadequate, data to prove it so should be accumulated from all periods during the plan's operation. The positive benefits afforded the riparian interests can best be illustrated by examining the huge accumulated positive deviation from the plan. This positive deviation represents a lowering of Lake Ontario which would not have been possible if the project had never been built and the plan of regulation never initiated. During a period of high precipitation, any regulatory plan can only serve to distribute the effects of the adverse conditions. In the case of high water condition, power and navigation have distinctly opposite goals. In actuality, during periods of high water levels on Lake Ontario, high flows through the power dam benefit upstream riparian interests and power, yet are a detriment and hazard to navigation and

downstream riparian interests (for reasons as pointed out herewith and in the report). Yet in periods of low water levels on Lake Ontario, this relationship is reversed. That is, the low flows through the power dam benefit upstream riparian interests and upstream navigation, yet are a loss to power, downstream riparian interests and also downstream navigation, since levels in Montreal-Lake St. Louis are at or below the minimum profile.

[*The text was expanded, including a figure reflecting preproject and experienced lake levels, to discuss this subject.*]

The report contains a number of other findings and corresponding recommendations, some of which obviously should be given further consideration. I would suggest, however, that this consideration be cautious and studied, for the implementation of a number of the recommendations such as the renegotiation of the applicable international agreements might well result in a worsening of the situation for those interests that the report proposes to protect.

[*The recommendations were reexamined in light of the comments received. Several changes were made.*]

As I have previously indicated, the plan has, in my opinion, served its intended purpose, but this is not to say that we should not continually review and revise it. Dr. Palm's report, when corrected, could serve as valuable input to the on-going project of the St. Lawrence River Board of Control to review, revise and improve the plan.

In closing let me say that I greatly appreciate the opportunity to review your draft report and hope that the comments contained in this letter will prove beneficial to you as you prepare the final report to be submitted to the New York State legislature and I look forward to seeing the final product.

Sincerely,

William H. Kennedy

William H. Kennedy
Resident Manager

BLACK RIVER–ST. LAWRENCE REGIONAL PLANNING BOARD

LEWIS JEFFERSON ST. LAWRENCE FRANKLIN counties

R&D Center, St. Lawrence University, Canton, New York 13617 (315)379-5355

January 20, 1975

William E. Tyson, Executive Director
St. Lawrence-Eastern Ontario Commission
317 Washington Street
Watertown, NY 13601

Re. Draft - "Analysis of and Recommendations Concerning High Water Levels on Lake Ontario and the St. Lawrence River

Dear Mr. Tyson:

We have reviewed this draft and find it to be acceptable as to writing, development of background information, and presentation of recommendations. "Finding 1" and its associated three recommendations is especially welcomed and strongly endorsed. Review time 5.5 hours.

Sincerely,

Donald S. King
Regional Planner
Environmental Health Services

DSK/pas

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Great Lakes Environmental Research Laboratory
2300 Washtenaw Avenue
Ann Arbor, MI 48104

January 21, 1975

Mr. Daniel Palm
Associate Economist
St. Lawrence-Eastern Ontario Commission
317 Washington Street
Watertown, NY 13601

Dear Mr. Palm:

Thank you for the opportunity to comment upon the water level forecast portion of your draft report entitled Analysis of and Recommendations Concerning High Water Levels on Lake Ontario and the St. Lawrence River. My comments on the report as discussed with you by phone are:

1. In Table 9, add Water Levels of the Great Lakes, Weekly Summary, a copy of which is attached.

   [*Referenced publication was added to Table 9.*]

2. On page 56, Methodology, the method discussed is currently employed by the Detroit District, U.S. Army Corps of Engineers, and not the Lake Survey Center.

   [*The section on lake level forecasting was rewritten in light of this and other comments.*]

3. The Lake Survey Center is now a unit of NOAA's (National Oceanic and Atmospheric Administration) National Ocean Survey and not the Corps of Engineers.

   [*The author was aware of this as is indicated on page 51 of draft text.*]

4. The NOAA component currently involved in lake level forecasting is the Great Lakes Environmental Research Laboratory of the Environmental Research Laboratories. We are currently using a climatological approach in our lake level forecasts.

   [*The section on lake level forecasting was rewritten in light of these and other comments.*]

5. The current 6-month and 1-month water level forecasts are coordinated between the Detroit District, Corps of Engineers and the Great Lakes Environmental Research Laboratory, NOAA.

I would appreciate receiving a copy of the final report when it becomes available.

Please contact me if further information is required.

Sincerely yours,

Frank H. Quinn

Frank H. Quinn
Head, Lake Hydrology Group

Enclosure

cc: Dr. Aubert

INTERNATIONAL JOINT COMMISSION
UNITED STATES AND CANADA
WASHINGTON, D.C. 20440

14 February 1975

Mr. William E. Tyson
Executive Director
St. Lawrence - Eastern Ontario Commission
317 Washington Street
Watertown, New York 13601

Dear Mr. Tyson:

This is further to our letter of January 29, 1975, in which initial comment is given concerning your December 1974 brief on the water levels of Lake Ontario and the St. Lawrence River.

I have attached a number of comments which include information received from Commissioners and members of our Board.

A parallel letter is being sent by the Chief Engineer of the Canadian Section of the Commission.

Sincerely yours,

Stewart H. Fonda, Jr.
Engineer Adviser
United States Section

enclosures: as stated.

SHF/cs

COMMENTS ON THE ST. LAWRENCE-EASTERN ONTARIO COMMISSION DRAFT REPORT

GENERAL COMMENT

1. While it is without question that the author has expended a great deal of time and effort, the general impression left by this report is that it is narrow in view and not completely factual. The overall conclusion of the report is that the regulatory system is operated primarily for the benefit of power and navigation interests with almost no consideration of the riparian interests. The objectives, as stated on page 2 of the report, are limited to an evaluation of the two years, 1973 and 1974, which were years of record levels and flows exceeding those upon which the regulation plan was formulated. It gives no recognition to the 13 years of regulation from 1960 through 1972, which included very low levels and flows, and in which overall benefits were derived from regulation, The objectives more desirably should have been to evaluate the effectiveness of the operation over the full period since the construction of the navigation and power project, and compare this with the history of levels and flows in nature before the regulation plan. Even if the SLEOC objective was limited to evaluating the extremes rather than the complete cycle under the current plan, the least that should have been done would be to also include the two lowest flow years (1964 and 1965).

[*A section was added to the report discussing the preproject and actual water levels. See Figure 29 and accompanying text.*]

2. The Board is currently working on a revision to Plan 1958-D, which incorporates supply data covering the 20 years since 1954. These studies are being conducted within the scope of the present criteria and existing physical constraints. The studies are examining the feasibility of incorporating lake level and supply forecasts into the regulation procedure.

[*The Commission encourages a speedy completion of this work. However, it also encourages a reexamination of the criteria.*]

3. The report fails to recognize the ability of the plan of regulation to operate with water supplies as received during the period 1860-1954 and the discretionary deviations that were made by the Board to cope with the sequence of record high water supplies in 1973 and 1974. Without the project, riparian interests would have suffered to a much greater extent. The report does not acknowledge that both navigation and power interests worked together for the benefit of the riparian owners, when in 1973 and 1974, water was allowed to spill over Long Sault Dam--water which then could never produce power and water which did, in fact, creat severe problems for navigation.

[*The question at issue is not whether the Plan of Control provides benefits but whether it maximizes these benefits.*]

4. The Seaway and Power Projects were designed and constructed under specific design criteria which, among other engineering considerations, established specific water levels, velocities and flows. These criteria were not set for the sole benefit of navigation and power, but for all interests, including riparian owners as well. These structures were paid for by the navigation and power entities, yet they have been of extensive benefit to riparian interests by permitting the operation of a control plan which has reduced the high levels of the past two years at all times from one to two feet below what they would have been under pre-project conditions.

[*This is understood by the author.*]

5. On pages 12 and 13 there are three questions implying a lack of informational input on regulatory decisions and a conclusion that there is both a lack of input and of impartiality in attempting to minimize the adverse effect. We cannot agree that the Board has not been fully cognizant of problems as they have arisen or that the Board has not acted to minimize adverse effects to riparian interests above and below the project area. In response to these allegations, and as noted above, it should be pointed out very strongly that since 1960 regulation has provided better than natural conditions for riparian interests on the Lake Ontario shoreline. The report speaks, on Page 21, of the need for "Additional efforts-- to derive a plan of regulation which will provide adequate protection for the natural environment of Lake Ontario and the St. Lawrence River." This can only imply that the natural environment is considered as the post-1960 environment. The point should be made that under regulated conditions the monthly mean levels of Lake Ontario at Oswego have ranged from a low of 241.78 in January 1965 to 247.92 in May 1973 for a total range of 6.14 feet; whereas, under preproject conditions, levels would have ranged from 241.52 in December 1964 to 249.03 in June 1973, or 7.51 feet.

[*It is not denied that the Board tried to minimize the damage to riparian owners given the institutional constraints and the lack of data. It is the latter two subjects that this report addresses.*]

6. The thrust of the criticism of the regulatory operation seems to be that releases were restricted, holding the level of Lake Ontario higher than it might have been with the present discharge capability. The critical assessment did not recognize that these releases were considerably in excess of those which would have occurred without the project, and that they were neeessarily restrained because of problems of flooding downstream.

[*Again, the question being addressed is whether the Plan of*]

Control as implemented allows for the maximization of benefits. The Commission feels that institutional constraints and the lack of data currently prevent this.

7. The suggestion that the IJC needs to collect data is not valid in that the IJC has available to it any and all data collected by agencies of both countries.

The text was expanded to indicate that the IJC does not have to collect the data itself but to make known what data it needs for decision making and then stimulate other agencies to collect it. The fact remains that the Commission feels that adequate data is not currently available upon which to make decisions.

8. The discussion concerning the use of Criterion (k) is confusing. Statements are made that "this criterion should have been followed to a greater extent," and that "an internal inconsistency in the Plan, i.e., Criterion (k) makes it nearly impossible to implement the Plan effectively. Both upstream and downstream riparian owners cannot be provided all possible relief, as required by the Criterion, during times of high lake levels." A final statement is "that Criterion (k) is, as written, impossible to conform to." The report should clarify the authors concept of and remarks concerning its use. In our view, the latitude provided by Criterion (k) has been responsible for improving the results of regulation during the past two years.

The discussion relative to Criteria (k) was reworded.

9. In regards to the author's statement concerning meteorologic forecasting, the International Great Lakes Levels Board (IGLLB) conducted a very extensive investigation on this matter. It concluded that there is very little promise for forecasting precipitation for more than a few weeks. The IGLLB did find some improvement is possible in forecasting runoff into the lakes from precipitation which has already fallen on the tributary land areas. The benefits and cost of expanding the Great Lakes hydrometeorological networks would need to be studies to determine the most feasible and desirable expansion program.

The Commission encourages this study to be undertaken as soon as possible.

10. The report author implies that he "perceived," from events in 1972 resulting in high water level conditions on the upper Great Lakes, that the Board, using meteorologic and hydrologic forecasting, should have known what to expect. He refers specifically to the 20-month period of January 1973-August 1974. The extreme conditions on Lake Ontario were due largely to the extreme local supply received during that period. As an example, the excess of local basin supply above the average (1950-1970) for the period January 1973-August 1974 resulted in an additional 3.8 feet of storage on Lake Ontario. More

discussion on this is provided in specific comments below.

[*Since, on the average, 85 percent of Lake Ontario's supply comes from the upper lakes it seems logical that the fact that these lakes were well above average levels taken by itself would have required strong action on the part of the Board.*]

SPECIFIC COMMENT

Pg. 1, Para. 1 — Only two of the lakes are currently controlled by man. This control is based on a set of criteria established by the IJC and were developed thru a series of public hearings on the matter.

Pg. 1, Para. 2 — Man's ability to control levels has had the effect of lowering the extreme condition from that which would have occurred under unregulated condition and thereby has reduced the damage.

Pg. 1 Para. 3 — Technical soundness of plan and satisfaction of the criteria is determined from a 100-year test over historical supply conditions.

[*The introduction to the report was rewritten.*]

Pg. 5 Para. 3 Sent.1&2 — Lake Ontario reached its 1972 peak level of 246.75 on 16 July. The highest monthly mean elevation in 1972 was 246.72 in July and this was not in violation of the criterion (h) monthly mean level of 246.77 feet.

[*The elevation referenced in the text was footnoted to reflect it was a mean daily level. The monthly mean level was also provided.*]

Pg. 5 Para. 3 — Outflow of 310,000 cfs as incorporated into Plan 1958-D is not above the limitation specified for navigation requirements. The upper limit specified by criteria is a monthly elevation and can be exceeded during the month. The criteria is satisfied if the monthly average is equal to or less than 246.77. Agree that Lake Erie was at or near record level. However, Lakes Michigan-Huron which contributes most of the supply to these lower lakes was only 1-1/2 ft. above its long-term average but below the highs of 1952 and much below the all time highs. The flow was maintained at 310,000 cfs. This is the maximum outflow permitted under Plan 1958-D and was consequently the highest outflow that had been discharged since regulation began in 1960. From about mid-September to mid-October this flow was in excess of the maximum outflow limitation specified by Plan 1958-D for navigation requirements. The Lake remained approximately 0.4 foot above normal (1860-1970 average for Oct = 244.43, Oct 72 average - 244.82).

[*The text was reworded in light of this comment.*]

Pg. 6 Para. 1 Sent 2&3 — During this period, 13 October - 7 November, the lake fell 0.4 foot to a low of 244.50 on 7 Nov., and then rose 0.4 foot to an elevation of 244.90 on 15 December, which was equivalent to its elevation on 13 Oct, just prior to the flow reduction.

[*The paragraph was reworded to reflect data provided.*]

Pg. 6 Para. 2 Sent 1&2 — Lake Ontario's basin precipitation exceeded the average 9.38 inches. Precipitation on the entire Great Lakes Basin exceeded the average by 4.41 inches. The amounts by which the precipitation on the remainder of the Great Lakes basin exceeded average ranged from about 2-1/2 to 6 inches.

[*Typographic error was corrected. Tables 6 and 7 reflect rainfall data in detail.*]

Pg. 6 Para. 4 — Appendix "B" of Great Lakes Levels Board Study, pages B-129 to B-313, compares extreme supply conditions. These figures indicate that the most extreme supply conditions on Lakes Erie and Ontario occurred in the 1970-1973 period. However, this was not the case on the upper lakes. Since supply to the lower lakes is equal to Inflow+Local Supply, it can be concluded that the extreme conditions were due to the extreme local supply. Hence, the statement that much above-average supplies would continue is not necessarily so - If local supply would have dropped off, the total supply would have been near average.

[*Granted it would have been nearer average but still above.*]

Pg. 7 Para. 1 — See comment above.

[*The sentence referring to lake level use was deleted.*]

Pg 7 Para 2 — The Lake Ontario discharges were increased from a low weekly average of 233,000 cfs in the second week of January to a high of 350,000 cfs in the first week in June.

[*335,000 cfs changed to 350,000 cfs.*]

Pg. 7 Para. 3 Sent. 1 — The fact that the inflow exceeded the outflow for the period January - May 1973 or any other year is normal, since this is the period of the normal seasonal rise on Lake Ontario.

[*A sentence was added that stated this to be the normal case.*]

Sent. 2 From 245.39 on 1 January 1973, the Lake rose to 247.99 by the end of May.

Sent. 3 The average level for May of 247.94 exceeded its long-term (1860-1970) average for May by about two and one-half feet.

Pg. 8 Para. 1 The level dropped from about 246.8 in early August to 244.3 in mid-December.

[*Dates were added to clarify which lake levels were being referenced.*]

Pg. 8 Para. 2 This flow was measured at Massena, not Ogdensburg. The official Lake Ontario outflow is determined as the summation of all flows (i.e., powerhouse flow, spillage at Long Sault dam, lockage in the Wiley-Dondero Canal and various minor diversions) at the Cornwall-Massena section of the St. Lawrence River.

[*A footnote was added to clarify the gauge location.*]

Pg.8&9 Para. 4 Sent. 3 The monthly mean Lake Ontario levels for October, November and December 1974 were 244.52, 244.00 and 244.03, respectively. These values were 0.33, 0.36 and 0.33 foot, respectively, below the levels of October, November and December 1973.

The following is offered as an accurate amount of Lake Ontario level conditions for the past three years, 1972, 1973 and 1974:

The levels rose from near average levels in early 1972 to a very high level in July Of 246.72. This level did not violate the criterion (h) monthly mean level of 246.77 feet. The sudden rise in early June and July was primarily due to the extraordinary rains caused by Hurricane Agnes. The Lake then entered its seasonal decline and the level fell at a greater than normal rate into November, even after the outflow was reduced for navigation purposes on the St. Lawrence River. However, when the Lake begain to rise unusually early causing an increase in level of about 1/2 foot during the period 6 November - 16 December 1972, the Board began deviating from the Plan and flowing greater-than-Plan flow.

The greater-than-Plan flows continued in 1973, until the first week of October when it was necessary to reduce flows for navigation in the St. Lawrence River. During this period, record high outflows were recorded both during the winter (with ice conditions) and the summer.

Lake Ontario's 1973 levels remained high during the year because it continued to receive record high supplies. Despite the Board's efforts to discharge the maximum possible amount of

water from Lake Ontario, considering downstream conditions, the Lake peaked in May at 247.94 feet (highest since regulation began and third highest since record keeping began in 1860) which exceeded the upper limit of 246.77 feet as specified in the IJC Orders of Approval. However, the levels throughout this period were at least one foot lower than they would have been if the project had never been built.

Throughout the summer months the Board continued to use its discretionary authority by making releases in excess of Plan 1958-D and pre-project. In fact, for two months, June and July 1973, the outflow averaged 350,000 cfs which was the highest ever recorded since regulation began and prior to regulation. The Board's action caused the Lake level to drop 45 inches from the peak level to 244.27 ft. by the end of November 1973.

The Lake then began its seasonal rise and reached a level of about 245.85 ft. by the beginning of March 1974, which was about 4-1/2 inches lower than at the same time in 1973. The levels continued to rise due to the high supplies and, again, despite the Board's action (of flowing maximum possible), even during the winter ice cover period, Lake Ontario exceeded the upper limit criterion and it peaked in June at a level of 247.45 ft. This peak level was 1/2 foot below that of a year ago (1973), and it was about 1.4 ft. below what it would have been had the project not been built.

Following the peak in June the Board continued to use its discretionary authority in making flow releases which were as high as 340,000 cfs in late July and early August 1974, and the level fell approximately 3-1/2 feet to a December mean leve of about 244.0 ft. This level is about 0.3 foot below the level of a year ago and only 0.2 foot above the average for this time of the year. The lowest daily mean level recorded during the month of December was 243.95 feet. During portions of November and December 1974 were the first occasions in nearly three years that the level dropped below elevation 244 feet. Unless extreme high supply conditions continue in 1975, which cannot be reliably predicted, the Board expects the level to peak significantly below the 1974 peak level. This takes into account the existing storage on the upstream lakes.

[*A footnote was added reflecting the data provided. The text was examined in light of your commentary.*]

Pg. 9 Para. 1

Although the net effect of the excessive supply of water was certainly beneficial to the power interests, there were two adverse effects to power, brought about by the method of regulation, which should not be overlooked. The drawdown effect in the power pool, which is created

by the discharge of high flows through the powerhouses, reduces the hydrostatic head available for power generation. ~~Therefore, there is a static head available for power generation.~~ Therefore, there is a reduction in the electrical power produced from each cubic foot of water discharged through the powerhouses. Secondly, and more important, spillage of water through Long Sault Dam was necessary from mid-April through mid-September 1973, and again for a period of time in 1974, to discharge the high flows authorized by the Board of Control. The total volume of the spillage, which was equivalent to one foot of storage on Lake Ontario in 1973 and one-half foot in 1974, by-passed the Moses-Saunders Power dam and thus was unavailable for power production.

[*Power production records appear to verify that the increase in flow due to the high water levels more than compensated for the loss in efficiency.*]

Pg. 10 Para. 1 Sent. 3 — Regulation Plan 1958-D was designed to provide the design depths of the navigation channels.

[*This is understood by the author.*]

Sent. 6 — It is stated that "...riparian owners are at present not represented by a spokesman of their own." Mr. Robert D. Conner, Member of the International St. Lawrence River Board of Control, was nominated by the Governor, State of New York and is concerned with the interests of all the people of the State of New York.

[*Footnote 11, Chapter VI sets forth the Commission's feeling on Board representation.*]

Sent. 7 — Correct the last part of this sentence to read: "...conflicts with power, navigation and the riparian owners downstream."

[*The sentence was changed as suggested.*]

Pg. 10 Para. 2 — The Levels Board Study made available loss functions mentioned in this paragraph. By letter dated 4 November 1974, to Dr. D. Palm, from Mr. B. G. DeCooke, Detroit District, Corps of Engineers, the Lake Ontario generalized shore property loss functions used in the International Great Lakes Levels Board Study were made available.

[*The information received after the draft was printed. Text changed to reflect receipt of data.*]

Pg. 11 Para. 2 Sent. 1 — The economic impact on power from various modes of operation should also be considered.

[*The text was expanded to include a discussion of this impact.*]

Pg. 11 Para. 3 Sent. 1 — There is strong objection to use of terms "inadequate knowledge" in reference to Operations Advisory Group. A better phrasing of this sentence might be as follows: "...are currently made without definitive information on the relative economic impact on each interest."

[*The text was reworded as suggested. The fact still remains that without the data described as lacking in the text well informed decisions cannot be made.*]

Pg. 12 Para. 2,3 — Any modifications to the present plan of operation will utilize both hydrologic and economic evaluations for final selection.

[*No comment.*]

Pg. 12 Para. 5 — This report continually challenges the capabilities of the members of the Board. Suggest preparing a short biography of each member of the Board, giving affiliation, education, years of service, etc., similar to that prepared for the International Joint Commission.

[*The draft was reworded throughout to clarify the Commission's position. It was not the intent of the Commission to challenge the capabilities of the Board members but to discuss shortcomings of the Plan of Control and its implementation over the past few years. As the revised text reflects it is not so much the "doing" of the Board as it is the limits placed on them by the Plan which are subject to question.*]

Pg. 14 Para. 1 Sent. 1 — "Table reflects..." It is not known what table is referred to.

[*Reference to Table 1 was added.*]

Pg. 15 Para. 4 and 5 — It should be noted that the report is in error in stating that flooding in Lake St. Louis occurs with flows in excess of 500,000 cfs. In this regard, it may be that the recently initiated study by Canada and the Province of Quebec may conclude that Ottawa River regulation can be improved for flood control purposes, but this is an internal Canadian matter. Any proposed modifications to Plan 1958-D include investigating the effects of limiting the maximum outflow from Lake St. Louis.

[*Footnote 12 in Chapter IV clarifies the text relative to flooding in the Montreal area.*]

Pg. 16 Para. 1 — This is no justification whatsoever given for the statements in this paragraph concerning the International Joint Commission.

[*The text was expanded to clarify what is meant by "revamping".*]

Pg. 17 Para. 3 — The International Joint Commission presently maintains a program of data collection, analysis and design through the agencies with which the members of the International Boards are affiliated.

[*Text was added describing the data needs that are currently felt unfilled.*]

Pg. 17 Para. 4 — This statement implies that Plan 1958-D was exercised only to its full latitude. The fact is that, with few exceptions, regulated outflows have been equal to and, in most cases, in excess of the maximum outflow limits specified by Plan 1958-D since the fall of 1972.

[*It was stated and discussed throughout the text that the Board allowed releases above those called for by Plan 1958-D. However, exercise of this latitude was felt not to be adequate in preventing damages.*]

Pg. 18 Para. 2 — The IJC has attempted to investigate the impact of regulation studies on various entities by holding widely publicized Public Hearings throughout the Great Lakes on the report by the International Great Lakes Levels Board.

[*As stated in Recommendation 2-1, Institutions, imput in the planning stage would be beneficial.*]

Pg. 22 — Finding 3 3, page 22, is a recommendation of Great Lakes Levels Board contained in their report of December 1973.

The gage network development and pattern establishment is carried out by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data - a Canadian-U.S. Committee.

The existing institutional arrangements have been instrumental in data gathering efforts.

[*The Commission felt this was important and included it in their report.*]

Pg 47 Para. 2 Sent. 2 — The IGLLB Study states that it takes about 2-1/2 years for 50 percent of the total effect of a supply change to Leks Michigan-Huron to reach Lake Ontario.

[*This comment was included in the discussion of time lags in the response of the lakes.*]

Pg 47 Para. 3 Sent. 2 — Should state: "...flow of the St. Lawrence River at Massena, NY."

Pg 47 Para. 4 — The flow was measured at Massena, NY, not Ogdensburg, NY. The maximum outflow at Cornwall-Massena was

351,000 on July 11 and 21, 1973.

[*Reference to gauge location changed.*]

Pg 51 Table 8 should be headed, at Massean, NY rather than Ogdensburg, NY.

[*The Table was footnoted to indicate that the location of the gauge changed with the construction of the Power project.*]

Pg 51 Para. 1 Sent. 3 This sentence could be better stated as: "However, because of physical and institutional constraints, it has not been possible to prevent the lake from rising, at times, to levels which have resulted in substantial damage to both man-made facilities and the natural environment."

[*Sentence rewritten as recommended.*]

Pg 52 Para. 3 Description of Lake Level Forecasting method is described in a technical paper published in 1967. There have been a number of changes made to the method since that date. In this entire discussion no mention is made of Regulation Representatives' technique and its application.

Pg 59 Para 3 Outlook on lake levels made each month is employed as a guide to future release.

Pg 60 Para 3 Sent 1 Method uses a cycle correction factor to compensate for excess precipitation.

[*The section on lake level forecasting was rewritten.*]

Pg 65 Para. 4 Sent. 1 Sentence should be reworded: "A high rate of release at the control structure tends to draw down Lake St. Lawrence until such times as sufficiently steep gradient is established between the water level at the control structure and Lake Ontario, to maintain the outflow from Lake Ontario equal to the Power Dam release rate."

Pg 65 Para 4 Sent 3 The converse of the rewording in previous comment should be used to improve this sentence.

Pg 71 Para 1 This paragraph and its footnote are confusing if not incorrect. Suggest this: Outflows from the control structure can create problems for navigation under either high or low Lake Ontario levels. However, in either case, the reason is the same: the outflow through the control structure is high, relative to the discharge which would normally be flowing from

Lake Ontario at its given stage at that time.

[*The text was revised to include the recommended wording.*]

Pg 72 Para 1 — Not true- during low supply period and minimum discharge, levels in Lake St. Lawrence are high.

Para 2 — Not true for navigation in the various harbors on Lake Ontario where the level is very important. During periods of low supply, navigation downstream of the International Rapids Section can be very critical.

[*This section was reexamined in light of these and other comments.*]

Pg 74 Para 4 — Not true - the Moses-Saunders Powerdam has capability to pass flows up to about 325,000 cfs. Also, while the number of kilowatts per cfs is maximum at a flow of 270,000 cfs, it is not true that flows above 270,000 cfs have zero value for power.

[*The text was revised to correct the statement in the draft.*]

Pg 117 Para 2 — Damage occurs when combined flows of the Ottawa and St. Lawrence Rivers exceed 380,000 cfs. Do not agree with statement that major effect is due to backwater and that Montreal experiences little flooding.

[*Footnote 12, Chapter IV clarifies the flow data. Statements relative to area of damage and relative magnitude provided by representative of Dept. of Environmental Conservation.*]

Pg 119 Para 3 — We question whether accelerated erosion has occurred - the change in beach width may be due to increase in elevation of water.

[*On site inspection indicates erosion has occurred as evidenced by the uprooting of mature trees and other forms of vegetation.*]

Pg 124 Para 2 — Great Lakes Levels Board has developed stage-damage curves for shore property.

[*Additional data, as outlined in the text, is required to refine these stage-damage curves.*]

Pg 125 — The effect above Moses-Saunders Dam on riparian owners is questioned. During periods of high supply, Lake St. Lawrence levels are lower than during periods of low supply.

[*Riparian owners above Moses-Saunders Dam include those not only on Lake St. Lawrence but also Lake Ontario.*]

Pg 126 Para 1 and 2 — These paragraphs are biased in only evaluating one short period. Consideration should have been given to total period of regulation to determine how much

a given interest has been benefited or damaged.

[*This study was directed toward examining a period of high water. It was not possible to examine the entire time period during which control has been effectuated.*]

Pg 126 Para 3 — False - This statement implies that Plan 1958-D was exercised only to its full latitude. The fact is that, with few exceptions, regulated outflows have been equal to and in most cases in excess of the maximum outflow limits specified by Plan 1958-D since the fall of 1972. From December 1972 to the summer of 1974, the St. Lawrence Board of Control authorized the discharge of a volume of water equivalent to approximately four feet of storage on Lake Ontario in excess of the volume that would have been discharged under the strict application of Regulation Plan 1958-D.

[*The author is aware of this and address this throughout the text. Since the Board has upon several occasions suggested they did all they could it was felt that the full latitude of the Plan had been exercised.*]

Pg 127 and 128 — A. Regulation of the Water Level. This section is very good except for the few comments below. Unfortunately its value is minimized by its rather obscure location in the report. Something is apparently missing in line 15, page 128, otherwise what does "both" refer to? The St. Lawrence Control system was designed to handle the extremes of the past (1860-1954) and to satisfy the IJC criteria for regulation - do not agree with 2nd sentence of the 1st paragraph, page 128. It is suggested that line 17, page 128 be changed to "...flow, but rather somewhat reduced range,..."

[*Several words were omitted in the draft. They have been included in the final report.*]

Pg 129 Para 1 — Do not agree. Regulation during period of high supply did not satisfy criteria, but reduced the peak levels below those which would have occurred under nature. Thus benefit has been provided during the 1972-74 period.

[*It is felt that if man is unable to manage lake levels as he desires then the lakes can said to be uncontrolled.*]

Pg 153 Para 4 Sent. 3 — It is interesting to note that the author implies that he "perceived" what Lake Ontario's hydrologic conditions would be for the 20-month period Jan 1973-Aug 1974. The following is given of the conditions for that period:

(1) Lake Ontario's local basin water supplied (NBS)

(does not include inflow from upstream lakes) was significantly above the 1950-1970 average NBS for 16 out of the 20 months of the period Jan 1973-Aug 1974. (2) The NBS for Mar 1973 exceeded the maximum NBS for March for the 1950-1970 period by 20 percent, which combined with the supply from the upstream lake caused Lake Ontario's level to rise by one foot during March 1973. This is about twice the average rise for March for the period 1950-1970 The excess of local basin supply above the average (1950-1970) for the period Jan 1973-Aug 1974 resulted in an additional 3.8 feet of storage on Lake Ontario, and this does not consider the additional supply from the upstream lakes.

[*The "perceived" refers to those involved in lake level regulation - not the author. The point being made is that the conditions as of Jan. 1973 called for certain actions and that the information gathered through the next 20 months did not add enough significant knowledge to change this required action.*]

Pg. 153 and 154 Para. 1

In general, the evaluation is based on the degree to which the IJC met the specified criteria during 1973 and 1974. Primarily, this referred to Criteria (I), (J) and (H). It should be pointed out that the criteria are prefaced on supplies as received in the past (1860-1954). The average rainfall in the Lake Ontario Basin from Jan 1973 thru Augst 1974 was 2.1 inches above normal.

[*The text was revised to make it clear that criteria (i) (j) and (h) are prefaced on supplies as received in the past (1860-1954) and that the average rainfall in the Lake Ontario Basin from Jan. 1973 thru August 1974 was 2.1 inches above normal.*]

Pg. 155 Para. 2 Sent. 2

"...measured at Massena, NY."

[*Point of measurement corrected.*]

Pg. 158 and 159 Para. 3 Sent. 4

This may be true if one would have known exactly what the future supply conditions to Lake Ontario, as well as upstream lakes, were going to be.

[*No comment.*]

Pg. 198 Para. 1

The Regulation Study is currently in progress.

Para. 2

Indicated approach to forecasting appears to be similar to studies made by Corps in the mid-50's (Beck).

[*No comment.*]

Pg. 215 through 234 There are some problems with figure and table numbers as related to those provided in the text.

[Figure and Table numbers were corrected.]

INTERNATIONAL JOINT COMMISSION

COMMISSION MIXTE INTERNATIONALE

151 SLATER
OTTAWA, ONT.
K1P 5H3

February 19, 1975

William E. Tyson, Esq.
Executive Director
St. Lawrence-Eastern Ontario
Commission
317 Washington Street
Watertown, N.Y. 13601

Dear Mr. Tyson:

I regret that it has been impossible to provide you, at an earlier date, further comments on the draft analysis and recommendations concerning high water levels on Lake Ontario and the St. Lawrence River. The Commission's report on the regulation of the Richelieu River and Lake Champlain was a high priority assignment.

In general, your document is a good synthesis of a number of reports. The author should be complimented for attempting to describe some of the natural phenomena and methodology. For example, he went to great pains to explain in layman's language the "backwater curves" on the Upper St. Lawrence, a subject so elementary to engineers familiar with channel hydraulics that they have never taken time to explain it in layman's language. His description of lake level forecasting was well done. Unfortunately, the method used by the Commission's Regulation Representatives is similar to that used by Environment Canada. That method, in addition to average precipitation, takes account of the probability of excessive or scant water supplies on the land and water areas of the Upper Lakes, as well as on Lake Ontario. A copy is enclosed for your information.

The economic analysis concerning navigation savings is one of the many methods used by economists. With regard to the statistical analysis, one should always bear in mind the statement made by the University of McGill's most honoured economist, "There are lies, damn lies and statistics".

One last general comment. On page 140 of your treatise there is a statement, "Only lake level regulation can provide the protection that is required for the natural environment... without destroying the area to be protected". Ironically

at the IJC Public Hearings in Plattsburgh on December 4, 1974, the official statement of the State of New York lamented the unfortunate emphasis placed on regulation as a solution to flood problems. The New York statement went on to say, "Our primary environmental concerns are the potential and possible detrimental changes to wetland areas which could result from reducing the height and duration of seasonal flood peaks." This is contrary to the general thesis set out in your report.

Given the current level of knowledge the Commission feels that lake level regulation is required to protect the natural environment. However, as stated in Recommendation 4-3, Data, Research, additional data is required. When this becomes available a change in attitude may be required on the part of the Commission.

The more obvious omissions and errors were outlined in letters from this Commission dated January 23 and January 29, 1975. Mr. Fonda, the Engineering Adviser in Washington, on February 14, sent further comments. I understand others have also forwarded their comments to you. Since I agree with their comments, they will not be reiterated in this letter.

It is hoped the comments set out below will be of value and integrated into your final document. If you wish to be cognizant of all the comments sent to you, it appears that the document should be rewritten with further technical aid in order to transform it into an accurate and objective report with creditability and worthy of serious consideration.

Page 11, Last Para.

The allegation that those persons who made the decision on the Lake Ontario outflows do so "under conditions of inadequate knowledge" and that they are "biased by the fact that they are employed by specific interests - riparian interests not included" is unfounded and false.

Footnote 11, Chapter VI clarifies the Commission's position regarding representation on the St. Lawrence River Board of Control.

Page 12, Last Para.

This paragraph appears to summarize the purpose of the brief. Unfortunately, the author does not understand the operation of the International Joint Commission and its International Boards, including the International St. Lawrence Board of Control. Such statements degrade an objective report

to an advocate's brief.

[*This section was revised and placed later in the report in the section discussing lake level regulation.*]

Page 15, Finding 3

This finding is incorrect. The figure 500,000 should be changed to read 380,000.

[*Footnote 12, Chapter IV clarifies the conditions under which flooding occurs in the Montreal area.*]

Page 15, Recommendation 3

The Ottawa River should remain under control of Canadians since it is wholly within that country or until they can control shoreline use in New York State. Quebec shore property interests should not be required to suffer more damage than would occur under pre-project conditions. Storage in the Ottawa River Basin is rather limited. Shore property interests in the Ottawa Basin, like the citizens of New York State, are also concerned about high water and preserving the environment. The author does not appear to have made a detailed study of the effectiveness of the International Joint Commission in dealing with boundary water problems that are of major concern to both Canada and the United States.

[*Precedent for international development of water resources has been set by the Columbia River Treaty. Such an approval may be useful for the St. Lawrence River drainage basin.*]

Page 17, Recommendation 5

The author does not understand the relationship of the International Joint Commission with the relevant data collecting agencies in both Canada and the United States. The International Joint Commission should not develop into a bureaucracy duplicating the functions of existing governmental agencies.

[*As indicated in the revised text the IJC does not have to become a data gathering agency. What it has to do is make known its data needs to the agencies established to gather data.*]

Page 17, Recommendation 6

Additional studies, which take into account the unprecedented water supplies of the last few years, are being conducted by the St. Lawrence Board of Control. One must bear in mind the physical and constitutional constraints.

[*This Commission urges a speedy completion of these studies.*]

Page 17, Finding 7

The regulation philosophy in this finding is not that of the International Joint Commission, but part of the criteria used by the International Great Lakes Levels Board in assessing various regulation plans for the Great Lakes System. The main complaint has been against high water levels in Lake Ontario. It should be understood that nearly all of the property damage occurs during storms and consequently the direct result of wave action. During the period when storms are most frequent, the levels of Lake Ontario, in the last few years, have been about two feet lower than those levels which would have occurred had not the St. Lawrence Project been built. Some estimate that the damage due to wave action is four times greater than that caused by inundation.

[*Since the IJC established the International Great Lakes Levels Board to study a specific problem it was felt that basic assumptions and criteria underlying the study most likely reflected the philosophy of the agency creating the study group.*]

Page 42

The chart would tell the whole truth if pre-project levels were also plotted.

[*A comparison of pre-project and actual lake levels was added. See Figure 29 and accompanying text.*]

Page 74, Para. 4

The statement that "any flow in excess of 270,000 cfs is of zero value to the production of electric power" is incorrect. The maximum flow that can be utilized is about 320,000 cfs. The output by the hydro-electric plants is increased by about 200,000 kw when the flow is increased from 270,000 to 320,000 cfs.

[*The text was revised in light of comments from the Power Authority of the State of New York.*]

Page 96, Para. 2

It is inferred that high water levels have a significant increase on power production. It is the outflow from Lake Ontario, not the level of the Lake, that is a major factor in power production.

[*This is true. However, during the period in question both high levels and flows occurred.*]

Page 126, Last Sentence

This statement is not correct and should be deleted. During the spring and summer of both 1973 and 1974, navigation was subjected to serious hazards. The water releases from

Lake Ontario was not a "windfall" gain, but actually a loss because water was spilled at Long Sault Dam. It should be stressed that the riparian owners derived an appreciable benefit because the lakes were one to one and a half feet lower than they would have been under pre-project conditions.

Navigation problems are well documented in Chapter IV, Section A-2. The gain referred to is the 20% above the average production that was possible at Moses Power Dam. Reference to the lowering of the lake due to the implementation of the Plan of Control was included in the revised text.

Page 155, Para. 4

It is apparent that the author does not understand the meaning of the term "maximum dependable flow". It has nothing to do with flows of 270,000 cfs.

The author understands the terms. Granted that over the long run the maximum dependable low of the St. Lawrence River is less than 270,000 cfs. As used here 270,000 cfs is not inferred to be the dependable flow but a figure to use in examining percentages of time actual flow exceeded a given flow.

Page 158, First Sentence

The statement that Criterion (h) has not been made with any degree of consistency is incorrect. If one considers the supplies that have occurred in the last 114 years, Criterion (h) has only been exceeded in two years. This indicates that Criterion (h) has been met with a very high degree of consistency. Furthermore, it stresses the unprecedented supplies that have occurred in the 20 months examined by the author. This comment also applies to Criterion (i) in the next paragraph.

Within the time frame of this analysis the referenced criteria were not fulfilled with a high degree of consistency. Granted, the period examined is one of high water levels.

Yours truly,

M. W. Thompson
Chief Engineer

MWT:ab
Enclosure

STATE OF NEW YORK

HUGH L. CAREY, Governor

ST. LAWRENCE - EASTERN ONTARIO COMMISSION

JOSEPH A. ROMOLA
Banking Executive/St. Lawrence County
Chairman

RICHARD R. MACSHERRY
Motor Transport Executive/Jefferson County
Vice-Chairman

WILLIAM L. CURTIS, JR.
Educator/Jefferson County
Secretary

St. Lawrence County
SAM AGATI/Labor Leader
DR. HERMAN L. SHULMAN/College Dean
RUSSELL B. STRAIT/Insurance Executive

Jefferson County
LEWIS V. BRANCHE/Banking
E. RUPERT WAGER, JR./General Contractor

Oswego County
HUGH NICHOLSON/Dairy Farmer
EUGENE SALOGA/Municipal Government

Cayuga County
CLAIR CONROY/County Legislator

At Large
MRS. JANE GRAY COX/Community Leader
DR. RICHARD PENTONEY/College Vice President

Ex Officio
HON. OGDEN R. REID
Commissioner
NYS Dept. of Environmental Conservation

Commissioner
NYS Dept. of Commerce

HON. STEPHEN BERGER
Director
Office of Planning Services

COMMISSION STAFF

Administration
William E. Tyson
Executive Director

Edward H. Cole
Counsel

G. L. Harder
Director of Planning

Peter C. Strakulski
Public Information Officer

Steven N. Meyer
Senior Cartographer

Ann Marie Carlisle
Senior Account Clerk

Land Resource Analysis
Thomas M. Cutter
Senior Natural Resource Planner

Roger J. Case
Senior Soil Scientist (IPA)

Water Resource Analysis
Barbara J. Rockhill
Senior Aquatic Biologist

R. Dennis Faulknham
Conservation Biologist

Program Development
Daniel J. Palm
Associate Economist

John E. Shattuck
Senior Statistical Clerk

Stenographic Services
Jan M. Lozo
Secretary to Executive Director

Ardis M. Bolton
Senior Stenographer

Constance A. Adderley
Stenographer

Chazelle Blanchard
Stenographer

ST. LA[illegible]RIO